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ABSTRACT

This book summarizes research on the various ways that students' cultural backgrounds and innate ways of learning affect academic achievement. It also offers descriptions and recommendations for improving science and mathematics education for minorities and women, based on successful programs, that take these differences into account. The focus is on the development of constructive educational, environments in which women and minorities are offered enhanced opportunities to gain knowledge and to explore new technologies in math and science. The following eight chapters are included: (1) Introduction; (2) Spending Time on Learning; (3) Recontextualizing Tasks; (4) The Classroom Level; (5) Computers' Impact on the Context of Instruction; (6) Activity Systems at the Level of the School; (7) The School in the Community; and (8) Conclusions and Recommendations. A 10-page list of references is included. The appendix lists a subcommittee of 31 scholars whose deliberations as part of a committee to address how the context of instruction affects learning helped to produce this book. (VM)

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Improving science and mathematics education for minorities and women

Contextual factors in education

editors **Michael Cole and Peg Griffin**
Laboratory of
Comparative Human Cognition

prepared for Committee on Research in Mathematics,
Science, and Technology Education

Commission on Behavioral and
Social Sciences and Education

National Research Council

Wisconsin Center for Education Research
School of Education
University of Wisconsin–Madison
Madison, Wisconsin
1987

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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The mission of the Wisconsin Center for Education Research is to improve the quality of American education for all students. Our goal is that future generations achieve the knowledge, tolerance, and complex thinking skills necessary to ensure a productive and enlightened democratic society. We are willing to explore solutions to major educational problems, recognizing that radical change may be necessary to solve these problems.

Our approach is interdisciplinary because the problems of education go far beyond pedagogy. We therefore draw on the knowledge of scholars in psychology, sociology, history, economics, philosophy, and law as well as experts in teacher education, curriculum, and administration to arrive at a deeper understanding of schooling.

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Foreword

The Committee on Research in Mathematics, Science, and Technology Education was established in the Commission on Behavioral and Social Sciences and Education of the National Research Council in 1984 in response to a request from the U.S. Department of Education. Its initial tasks, for that department and the National Science Foundation, were to develop a set of research priorities and to consider the role of multidisciplinary research for science, mathematics, and technology education. That work resulted in two reports, *Mathematics, Science, and Technology Education: A Research Agenda* (National Academy Press, 1985) and *Interdisciplinary Research in Science, Mathematics, and Technology Education* (National Academy Press, 1987).

While preparing the first report, the committee became interested in exploring in more depth two issues: how children learn reasoning and other complex thinking skills, and how the school environment can be manipulated to maximize opportunities for children to succeed in learning science and mathematics. Work on the first issue was undertaken by Professor Lauren Resnick at the Learning Research and Development Center of the University of Pittsburgh and resulted in the paper *Education and Learning to Think* (National Academy Press, 1987). Work on the second issue was carried out by Michael Cole, Peg Griffin, and their colleagues at the Laboratory of Comparative Human Cognition at the University of California at San Diego. Carnegie Corporation of New York is generously supporting wide distribution of both volumes.

The Wisconsin Center for Education Research is delighted to join the National Research Council in publishing the second paper. The Center is committed to three principles that permeate this paper: that the educational opportunities for women and minorities in the United States must be improved, that the knowledge base to make important improvements is being developed, and that major, perhaps radical, approaches that build on the knowledge base may be necessary. In support of these principles, Michael Cole and

Peg Griffin, in concert with over 30 other researchers from across the nation, have pulled together an extraordinary and challenging range of ideas, findings, and speculations—in a very engaging paper.

This paper comes at an opportune time. The nation's educational systems have survived a recent major burst of reform. By many accounts the reforms have been successful: the quality of teacher training is undergoing intense scrutiny; greater numbers of talented college students are entering the teaching force; more students are taking high school courses that will enable them to qualify for college admission; and, especially in the South, education has become a top priority of state governments. By other accounts, however, the reforms have ignored the most pressing problems of American education: relatively few of the state reforms addressed the most needy in the nation's schools—the poor, those whose English is limited, and very low achievers. The percentage of children in poverty has markedly increased since the early 1980s; the dropout rate in many places has increased; and the range of college attendance among blacks has declined. For many students, the opportunities are fewer now than they were before the reforms.

Cole, Griffin, and their colleagues address the issue of creating constructive educational environments for women and minorities, especially in the content areas of mathematics and science. They review the results of recent interesting and successful interventions; they poke holes in some of the superficial policy proposals—such as "increased time on task"; and they explore the possibilities for using new technologies to enhance opportunities. The paper may be usefully read by a public interested in educational issues, by teachers and administrators who wish to improve their school systems, and by social and behavioral scientists who are engaged in developing new knowledge. We are pleased to be involved in the publication of this paper.

Marshall Smith	Carl Kaestle
Former Director	*Director*

Wisconsin Center for Education Research

Acknowledgments

This report is the result of a group effort over an extended time period. Although we are listed as Editors of the resulting monograph, along with the Laboratory of Comparative Human Cognition, we acted far more as collators of the members' contributions.

We urge readers to turn to the Appendix, which contains a brief description of the process of compiling the report and the names of the contributors who are the real authors.

We acknowledge the support of several people and institutions in completing this work. First and foremost, we are deeply indebted to Peggy Bengel and Karen Fiegener, who gave unstintingly of their time to coordinate all of the contributors and the resulting texts.

The W. T. Grant Foundation, through the Committee on Research on Mathematics, Science, and Technology Education, and the Carnegie Corporation of New York provided financial resources support for this work. We also express our appreciation to Senta Raizen, the study director of the committee, for her assistance throughout the work and publication of this paper.

Michael Cole and Peg Griffin

1: Introduction

The purpose of this review is to arrive at a research agenda addressed to ways in which increased knowledge of contextual factors in education can enhance the basic academic skills and participation in technological literacy by far more of our population. Along with the parent NRC Committee that generated this report (the Committee on Research in Mathematics, Science, and Technology—James March, Chair), we have worried about the vast educational potential waiting to be tapped among a variety of groups that are underrepresented in the technological activities of our society, especially women and ethnic minorities. We have focused on how to use new technologies as a vehicle for general educational improvement, in addition to considering their use as a goal of a specific part of the technical curriculum.

Underlying Concerns

Underlying our specific focus on underrepresented population groups was the shared perception of committee members that the problem of underrepresentation in higher levels of the educational system by certain populations has reached disastrous proportions in this country. In southern California, for example, more than half the Hispanic-American children who enter the school system drop out before they complete high school; less than 10 percent of Hispanic-Americans from southern California enter the University of California. Yet, in many areas of southern California, Hispanic-Americans are an absolute majority of the citizens whose educational needs serve as the *raison d'être* for the public support of a university. Analogous problems exist in other parts of the country and for other populations.

This situation is so obviously dangerous from a political and economic point of view that it deserves the serious concern of policymakers and the academic community, as well as the military and the business community. We assume the problem of widespread undereducation to be a common concern underpinning this report.

The diffuse nature of factors included under the rubric of context required us to create an investigatory framework that could confront the diversity of the problems with an adequate diversity of solutions. Our group was highly interdisciplinary, including specialists in psychology, sociology, linguistics, anthropology, and education. We took it as our task to come up with recommendations based, insofar as possible, on methods and canons of evaluation acceptable across a variety of disciplines so that we would be confident of their scientific foundation. At the same time, the interdisciplinary nature of the problems insured that methodological and measurement issues would loom large as a problematic element in our review of the field.

It is the Committee's view that the obvious difficulties of the current educational situation represent a period of great promise as well as a period of threat for American education. In particular, it appears that existing research has identified a set of social systems properties which, when implemented, sharply improve the educational achievement of a great many children who otherwise would drop out below the needed level of technological literacy. The problem is that educational programs successful in the "hothouse" of social science interventions do not have staying power when the hothouse supports are withdrawn.

It seems clear, from a variety of public opinion polls and analyses of educational activities in different sectors of society, that the American public is not going to provide expanded budgets to existing educational institutions for extending the school day, extending the school year, reducing the adult-child ratio, or other personnel expenditures that might promote the generalization of the intervention experiments. Yet there is great pressure for increased educational performance. That contradictory set of social constraints can be reconciled with increased achievement only if a significant reorganization of existing educational resources is somehow carried out. There need to be serious proposals for redirecting existing expenditures. It is precisely at this point that we see the special opportunities associated with new information technologies, including interactive computer communication and interactive video pedagogies. New media of communication offer one potential for institutional realignments that might yield solutions to current problems.

Unfortunately, existing evidence strongly suggests that, in addition to its promise, a new technology of communication is causing a new epidemic of imbalanced knowledge acquisition, instead of a rise of educational excellence across the board. Therefore, special attention has to be paid to the growing disparity between potential for reorganizing diverse people in educationally productive ways on the one hand and the consequences of the current way that new technologies are introduced into the schools on the other.

We will return at the end of this report to summarize recommendations for research and policy that appear to be implied by our review of the facts. As will be demonstrated repeatedly, *excellence can be organized.* The challenge is to distill the lessons learned from locally successful systems and to determine under what conditions they can be generalized.

There has been a great deal of work demonstrating that American schools may be organized for social purposes other than academic excellence—schools are also sorting devices and credentialing bureaus that select among the members of the population in the service of social institutions such as industry (Mehan, 1983; Snow, 1982; Spring, 1976). While we would not deny the validity or importance of research on these other social functions of education, our attention here is to schools as transformation institutions that arrange for the development of the knowledge and skills with which students enter. The tension between the selection and transformation functions of schooling is not unique to the U.S. and will continue to be a matter of international concern, which, although somewhat independent of the issues raised here, may be informed by this discussion.

Similarly, we appreciate that economic and political pressures should loom larger than is reflected in the body of this report. Schools with large populations of minority students are usually located in communities with small tax bases or in large urban areas with declining fiscal resources (Sheingold, Martin, & Endreweit, 1985). The resulting fiscal limitations make it difficult for these schools to keep pace with educational innovations, not only in terms of equipment and supplies but also in terms of attracting new staff and providing the training necessary to keep existing staff abreast of the latest developments in educational research and technology. Outside sources of support for educational programs in schools attended by minorities are often earmarked for educationally disadvantaged children. While this support may provide resources needed to give minority children access to newer educational technologies, it often comes attached to two sorts of restrictions that minimize the extent to which the technologies can be effectively employed.

First, restrictions are introduced in relation to the kind of educational program that the new technology fits into; computer use in Chapter I programs, for instance, is largely limited to the kinds of drill-and-practice instruction that characterized the educational program before the advent of the new technology (Center for the Social Organization of Schools, 1983-84). Second, there are restrictions that minimize the use of the new technology to enhance the education of children who are doing well—at or above grade level. These restrictions limit the diffusion of new technology in urban and rural schools with large minority populations and simultaneously decrease the possibility of inventing educational activities that go beyond what is already known, i.e., the drill-and-practice activities.

Not only economic pressures but political ones are operating in the same settings. Administrators and teachers in districts with large minority populations are often under considerable pressure to reduce dropout rates and increase achievement test scores. This pressure comes from employers and policymakers concerned about the trainability and productivity of workers with basic skills deficiencies (Carnegie Corporation, 1984-85; Hunter & Harman, 1979) as well as from parents worried about children's prospects for employment and higher education. Communities can hardly fail to respond to the bleak educational statistics: the dropout rate for Hispanics and blacks is about double that of whites; although minorities comprise 25 percent of the school population, they represent 40 percent of the students suspended or expelled; and the average performance of blacks and Hispanics on the Scholastic Achievement Test is over 50 points lower than the means for Anglo students (Carnegie Corporation, 1984-85). Thus, it is not surprising that educators of minority students are pressured to "do the basics" better and leave innovative educational practices to others. However, a continued imbalance in the educational mandates that guide the education of minorities and of white middle-class children deepens the problem: as schools serving minority children focus their resources on increasing the use of well-known methods for drilling the basics, they decrease the opportunities for those children to participate in the higher level activities that are needed to excel in mathematics and science.

Our report does not have the scope to analyze the economic and political pressures and recommend solutions to the apparent binds, but we believe that our discussion can contribute to such analyses and action as we indicate the points of change within schools that can be productive. According to the extensive and sophisticated study of technology and society undertaken by the Conservation of Human Resources project at Columbia University (e.g., Noyelle, 1985), new technologies and new economies call for more emphasis on effective off-the-job training for many sectors of industry. Hence, it is important to identify points of change within schools.

With these comments in mind, we turn to a systematic survey of the issues involved in addressing the role of context factors in educational achievement.

An Embedded Context Framework

Our deliberations began with an attempt to define the basic terms we had been given to work with. It was not an easy job.

As a starting point we discussed what was meant by the distinction between cognitive and contextual factors influencing education. Starting first with the presumably better-understood side of the cognitive-contextual dichotomy, we defined cognitive factors influencing education to be the specification of the mental work that occurs when a child is doing a particular curriculum task. The implicit start of cognition, in this framework, is the posing of the task by the teacher. The end is the response produced and usually interpreted as the production of a single pupil. Cognition refers to the information processing that occurs between presentation of the problem and the response.

Cognitive factors may be subdivided in a variety of ways, depending on one's particular theory. And, cognitive factors may be attributed to an individual or to social "collusion" in a variety of ways, depending on another set of particular theories.

As a way of specifying a systematic constraint on our review of contextual influences on educational processes so that they could be more than everything that is not related to the task itself, we adopted the embedded contexts representation of our topic depicted in Figure 1.

According to this view, it is possible to identify a unit of analysis called a cognitive task. Cognitive tasks can be created experimentally, or they may arise when a student is confronted with a part of the curriculum and begins to spend time on the task (Bloom, 1976). The quantity and quality of the time on task can be used as a mediating variable of common interest to those studying both cognitive and contextual factors in education. The cognitive and contextual approaches differ in emphasis: The cognitive approach manipulates factors within the task; the contextual approach deals with the constitutional relations between the task and broader levels of context.

Although we have found a commonsense notion of context useful, it is important to emphasize that a noncritical acceptance of the commonsense division between task and context is an oversimplification that itself needs to be examined critically. For theoretical reasons as well as many problems of concrete research, it is inappropriate to equate *context* with *environment* (literally, "that which surrounds"). Two hints of the more specialized understanding of context with which we have grappled can be seen in our use of the phrase *constitutional relations* in the previous paragraph and our depiction of the task itself as one of the levels of context.

Even a simplified view of context such as "that which surrounds" is complicated. Context refers to the events preceding, occurring with, and following the cognitive task; context so conceived includes all the factors that might influence the quality of time spent on the task, ranging from

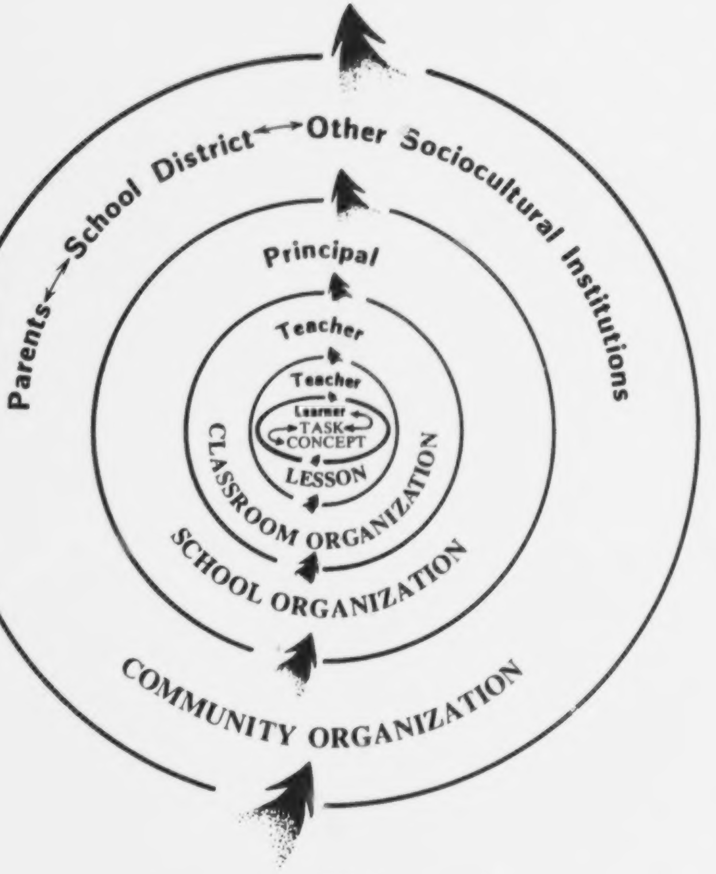
Parents↔School District↔Other Sociocultural Institutions
Principal
Teacher
Teacher
Learner
TASK
CONCEPT
LESSON
CLASSROOM ORGANIZATION
SCHOOL ORGANIZATION
COMMUNITY ORGANIZATION

Figure 1. Embedded Contexts.

the arrangement of a lesson in the curriculum, to the relation of the classroom to the school as a whole, and to the relation of the school to the community of which it is a part. From the original Latin term *contextere*, "to weave together," we obtain a close approximation of context as we conceive of it.

Within each level of this scheme it is also necessary to look at behavior in as many settings as possible to understand the range of variability that characterizes current educationally relevant cultural practices. The complexities of incorporating a rich interpretation of context underlie a great many methodological disputes in discussions of contextual factors in education.

Important Complements: The Example of Family Stress

One consequence of our organizational framework is that certain bodies of literature fall outside the scope of the work. Our approach to contextual factors provides a strategic avenue of access into the aspects of the problem that are contemporaneous with school performance, achievement or failure, and the aspects that are accessible to manipulation under the rubric of educational policy and practice. There is, however, a complementary body of literature, and perhaps a complementary report needed, with foci such as mental and physical health and affective factors, as well as issues of nutrition and social development. We think that these issues are complementary because, while they point to problematic aspects in the life of the children who are our main concern here, and while they point to problems that can clearly interfere with the achievement of academic excellence, they are less directly related to schools as currently constituted in our society than the research under review. There is clearly overlap and need for an eventual reconciliation of this subdivision between context factors closely related to the school and other context factors relevant to education. To exemplify this arena of overlap, we consider the case of stress and family circumstances.

Later we point to the importance of community and family involvement in effective educational programs; as we do so, we must consider the difficulties within families. An important limitation on the family's ability to serve as a resource for children is the degree to which parents are under stress for reasons having nothing to do with the immediate task of bringing up their children and seeing that they get a good education.

An experiment by Zussman (1978) demonstrated the influence of even minor stress on parenting styles which in turn have been related to educational achievement (see Maccoby, 1984, for a review). Zussman invited parents with two children, a preschooler and a toddler, to come to an observation room where there were both play materials and opportunities to get into mischief. Some parents were simply allowed to watch and help their children. Others were given a paper-and-pencil problem to solve while keeping an eye on their two children. Under these very mild conditions of stress, the preoccupied parents played less with their children, ignored attention-getting initiatives they might otherwise have responded to, and used more peremptory "short tempered" control strategies. The parental pattern that emerged under stress bears a striking resemblance to the pattern of child rearing that has been associated with a child's subsequent reduced scholastic achievement.

This same pattern appears in real life conditions when interviews and observations are combined to trace the relationship between stress and parenting styles. Forgatch and Wieder (summarized in Patterson, 1982) obtained daily reports from mothers about such stressful events in their lives as unexpectedly large bills, the illness of a family member, and quarrels with their husbands. The investigators also made periodic visits to the home to observe patterns of interaction between mothers and their children. They found that maternal irritability usually increased when things outside their specific relationship with their children were going badly. When they were irritable because of this stress, mothers were more likely to hit or scold their children and more likely to refuse to comply with their children's requests.

The kind of everyday circumstances that provide the background stress of child-rearing for many parents living in the United States today is illustrated by interviews with working-class mothers who have a three-year-old child to raise in addition to a full-time job:

> We don't have any kind of life. When you work, you're constantly racing around back and forth. There's never any relaxation. Work, come home and work, go to bed, etc., over and over. No respite. It's not my idea of living. . . . There's no way you can cram seven days of housework into less than 2 days (weekend). . . . Seems like I'm always running around on my lunch hour. There's so little time. (Bronfenbrenner, Alvarez, & Henderson, 1984, p. 1367)

It is not very surprising that the frequency of such stressful events is greater among poor families than the well-to-do ones (Brown, Ni Bhrolchami, & Harris, 1975) and is increased by father absence, early parenthood, and a variety of other forces that render family interactions uncertain. As a result, it is to be expected that studies in the United States and Britain (Bernstein, 1971; Kohn, 1977) would report that lower socioeconomic households have a high frequency of the child-rearing patterns associated with parental stress and reduced school success.

We must be very cautious about our judgments of the parenting practices of America's working-class and poor populations. Kohn stated the problem quite clearly:

> Since social scientists understand (and largely share) middle-class values, we find middle-class parental behavior [which emphasizes independence and self-direction] self-evidently reasonable. But because many of us have not had an adequate grasp of working-class values, it has been less apparent that working-class parental behavior is also reasonable. . . . Working-class parents are as concerned as are middle-class parents about their children's future. (Kohn, 1977, p. 197)

A crucial fact about socialization is that parents raise their children to confront the world as they understand it on the basis of their own experiences. There is a perplexing consequence of this convergence for societies like ours. Kohn (1977, p. 200) again pinpointed the issue: "The family, then, functions as a mechanism for perpetuating inequality." Some change in the pattern of the family's coordination with other social institutions (like schools, churches, unions, workplaces) is an approach that may break this perpetuity.

The educational dilemmas posed by the close links between problematic aspects of adult life in the community and the quantity and quality of the resources available for children are not unique to the United States; they reoccur in all industrialized countries. Pressures and inequities that make family life difficult certainly do not make the job of education any easier; however, such conditions should be taken neither as determinants excusing failures that are accomplished in the schools nor as a rationale for failing to find ways to obtain family and community input to educational programs, especially when coordination with family and community can be shown to be advantageous for school achievement.

While our organizational framework forces—or allows—us to give short shrift to the contextual factors like stress that are less institutionally linked to schools, we wish to underscore their interrelatedness with the issues we address and the general problem we are concerned with. As will be recognizable below, some effects of recontextualizing tasks, classroom organization, curricula, and schools are associated with changes in factors like self-esteem and higher expectations about achievement. However, the designs, methods, and measurement techniques—the technology of research—in the studies that can fall under our recontextualization rubric differ greatly from those that would be found acceptable by other scholars concerned with issues like stress, self-esteem, attributions, and expectations. An early recommendation, in fact, would be to provide for a critical review of the relationships between the two sorts of contextual factors in education. We suspect that there is room for productive interaction that could result in better theories and better research on both sides of this divide—and that could increase the utility of the research for educational practice.

Characteristics of Successful Programs

An important study conducted by the Office of Opportunities in Science (American Association for the Advancement of Science, 1984) provides hope at the outset that with serious efforts the educational problems of underrepresented groups *can* be overcome. This report summarizes data from 168 special programs and identifies the characteristics that produce successful mathematics and science education for underrepresented populations. Because of its strong affirmative nature, the basic conclusion of this report is worth highlighting:

> The evidence gathered to date indicates that if minorities and women are provided early, excellent and sustained instruction in these academic areas . . . then their achievement levels parallel those of white males. (AAAS, 1984, p. iv).

The report listed 16 characteristics of the successful programs:

1— Strong academic component in mathematics, science, and communications, focused on enrichment rather than remediation.
2— Academic subjects taught by teachers who are highly competent in the subject matter and believe that students can learn the materials.
3— Heavy emphasis on the applications of science and mathematics and careers in these fields.
4— Integrative approach to teaching that incorporates all subject areas, hands-on opportunities, and computers.
5— Multiyear involvement with students.
6— Strong director; committed and stable staff who share program goals.
7— Stable long-term funding base with multiple funding sources.
8— Recruitment of participants from all relevant target populations.
9— University, industry, school, etc. cooperative program.
10— Opportunities for in-school and out-of-school learning experiences.
11— Parental involvement and development of base of community support.
12— Specific attention to removing educational inequalities related to gender and race.
13— Involvement of professionals and staff who look like the target population.
14— Development of peer support systems (involvement of a critical mass of any particular kind of student).
15— Evaluation, long-term follow-up, and careful data collection.

16— "Mainstreaming"—integration of program elements supportive of women and minorities into the institutional programs.

These characteristics are, for the most part, self-explanatory, but some comments may be helpful regarding interaction of components and their relationship to classroom-level and school-level factors. With respect to classroom-level findings, the report supports the notion of peer-grouped curriculum with a good deal of hands-on work and a constant interplay between theoretical and practical activity. It also supports the conclusions of Berliner (1984) and many others that students should experience, and teachers should expect, high levels of successful performance.

At the level of schools, these programs have all the characteristics of a subculture. There are shared values and activities; there are multiple years of participation that ensure that there will be multiple generations of participants interacting at any one time. There is interaction not only between teachers and students but among students, as an essential facilitating factor. Point 13 is worth emphasizing; involvement of adult role models who are from the same population group as the students requires the participation of minorities and women in a supervisory role.

The programs are not isolated from the rest of the students' lives. On the one hand, there is the clear goal of mainstreaming at the end of the program. On the other hand there is community support and participation from parents at the start of the program and during its course. These features can be summed up by the idea that successful programs allow for vertical integration of the educational experience beginning at the start of schooling and continuing into the college years.

A major point stressed in the report is that the different categories of underrepresented populations should not be lumped together with respect to the particular program elements that should be emphasized. One template of a program cannot be found that can be superimposed in various places to produce effective learning. Local invention is needed not only in the planning but in the ongoing implementation:

> The variability among racial/ethnic groups and within a particular group is likely to be very great. Successful intervention programs learned early to smooth out the differences and at the same time to be sensitive to them. (AAAS, 1984)

The specification of group differences is too lengthy for inclusion here but well worth reading for anyone engaged in this line of endeavor. The 16 general characteristics listed above allow for some information exchange to guide local invention, but their appearance in an effective program is concretely related to the local language and cultural circumstances.

At the time the AAAS report was prepared, computer use was a rising point of interest. Note that communications is listed as an essential content area in the curriculum. These two aspects of the program are interconnected: computing is not just a topic in itself but a toolchest full of resources for all kinds of academic endeavors, and the report recommends a computer/communication component for such programs. The issues raised by the AAAS study will reverberate throughout this report; we will return to consider its implications in summarizing one of our recommendations for further research.

Organization of the Review

As an expository device, we will organize our review from the inside out, e.g., from the task to its context. We begin, in section 2, with a very brief discussion of limitations associated with time-on-task approaches to assessing how effectively the teaching/learning process is organized, relying on a simplified conception of context. We move in the following sections to a discussion of the levels of context depicted in Figure 1: recontextualizing individual tasks; recontextualizing the social organization of the instructional process, emphasizing the special case of linguistic and social variations and social organization; recontextualizations afforded by the advent of computers in education; the school as a distinctive cultural organization; and, finally, links between schools and various nonschool settings.

2• Spending Time • on Learning

Following the common-sense principle that learning takes time, much recent research on improving education has focused on "time on task," the time that students spend engaged in—attending to and participating in—academic work (Bloom, 1976). More refined concepts such as "active learning time" or "engaged learning time" have been constructed to measure effective learning time (Carroll, 1963; Harnischfeger & Wiley, 1981). Within the system of assumptions that permits a dichotomy between the task and its context, this approach treats contextual factors as independent variables that influence effective learning time (the mediating variable) and improved achievement (the dependent variable). A very solid body of research demonstrates that, when students spend time on tasks with high levels of success, their performance improves with increased time devoted to learning (Fisher, Berliner, Filby, Marliave, Cohen, & Deshaw, 1980). This evidence has made research on ways to increase the amount of time students spend on task an important topic for educational researchers.

While acknowledging the importance of research on time on task as one means of understanding the educational process, the simplifications involved in the operationalization of *effective* time on task have led, in practice, to some problems of their own. Since it is very difficult to know what is going on in children's heads, even under the most carefully designed experimental circumstances, time on task gets coded operationally, in terms of what the children are *not* doing; they are not whispering, not looking around, not sleeping, not away from their desks, or some other not. Time on the task is the residual of these other behaviors. The suggestions for classroom practice that are generated by this criterion also have a negative tint to them; they emphasize management tactics that keep the children from appearing to be off-task.

In reviewing the time-on-task and classroom organization literature, four areas of concern kept reappearing in our discussions. When time on task is inverted (viewed as a residual, equivalent to "not off-task"), the research depends on, and subtly validates, certain pedagogical assumptions, and it leaves some important matters uninvestigated and unresolved.

First, standardized time-on-task analyses seem to deal almost exclusively with (and to work most effectively for) teacher-led lessons and seat work. This connection seems altogether natural; if there is no adult discussion leader and the children are busy talking together as a part of their lesson, it is much more difficult for teacher or researcher to judge what is on-task and what is off-task behavior.

Simply on the basis of frequency of occurrence, it is not unreasonable that time-on-task studies should have focused on teacher-led lessons. Descriptive studies suggest that teacher-led whole groups predominate in American classrooms (Dunkin & Biddle, 1974; Goodlad, 1984). Teacher-led small groups are common but tend to occur primarily in early grades, and particularly in reading instruction (Cazden, 1986). Peer groups are infrequent in today's schools, but are more common in social studies and science than in other subject areas (Stodolsky, 1984). Sirotnik (1981) has reported findings from observations in 129 elementary school classrooms selected to represent varying community types nationally; he found only 2 percent of students engaged in cooperative groups.

These less frequent situations are difficult to code or engineer for common measures of on-task behavior. But these are the sorts of situations that we have found among the promising alternative modes of instruction, especially in science, mathematics, and technology education.

Second, discussions of the time-on-task literature often appear to assume that the number of students engaged in a lesson is equivalent to the number of students in the classroom. When the teacher deals directly with a subset of the class, good or bad time on task for that subset of the children cannot stand as a full measure for all the children in the classroom. How does the quantity of students directly involved with the teacher relate to the quality of instructional interaction for all the children in the class? In most of the effective learning time literature, an increase in quality of performance is produced by a combination of tighter control and fuller feedback. Thus, this literature promotes reduced teacher-student ratios (perhaps arranged by rotating children through teacher-led small group lessons) but fails to investigate any qualitative reorganization of instruction for the rest of the children in the class. In such an approach, the most effective management of time for students who are not working with the teacher becomes an issue. This assumption that reduction of size will bring no qualitative change in interaction is not a necessary conclusion, nor is it consistent with the facts.

An alternative is to reorganize the relationship of the students to the instructional materials and the teacher at the same time in a variety of alternatively structured groups. In this arrangement, the teacher becomes an advisor and facilitator rather than task presenter and central control mechanism.

There are many problems associated with a shift to decentralized classroom management, not the least of which is evaluation. But we should not compound the problems we set out to solve by using research designs and evaluation methods that subtly limit the range of solutions that can be considered.

Third, whatever options for reorganization are adopted, any attempt to measure, analyze, or engineer effective learning time needs to recognize the question of group heterogeneity. It should not be assumed that the effect of the degree of heterogeneity within an instructional group is independent of group size or of the organization of interaction within groups. It is quite possible that principles of small-group instruction and heterogeneity interact. Moreover, these two factors may well interact with curriculum content. Clearly, until these interactions are sorted out, prescriptions based on the time-on-task literature should not be taken too strongly.

Fourth, it should not be assumed (as much of the learning-time literature does implicitly) that the definition of *task* remains invariant across methods of organizing instruction in classrooms. We have reservations about the ability of a researcher, even a teacher, to recognize discrete tasks and their boundaries (and, hence, off-task behavior) in the ordinary life of the classroom (Griffin, Cole, & Newman, 1982), and these reservations increase as we consider the plausibility of locating "same" tasks in different social organizations (Newman, Griffin, & Cole, 1984). Yet, any notions that a task allows more effective learning time in one instructional arrangement (e.g., teacher-led small groups) than in another (e.g., children without adults in small groups) assume that the same task *can* be compared across settings. Other literature that recommends the superiority of reduced size instructional groupings, in fact, makes an opposite assumption: Tasks will not remain the same when the social situation of instruction changes; a reduction in the size of instructional groups can create a qualitative (not just quantitative) difference in the context, thereby creating a qualitatively different definition of the task by individual students. When such reorganization is achieved, it can transform the relationship between task success and what are usually called cognitive entry behaviors; a task may be easier or harder than a quite similar task encountered by the same person in another context. This emphasis is especially important for addressing the invention of successful programs for populations currently underrepresented in mathematics, science, and technology. Thus, section 3 explores the issue of modifying the ease of performance by changing task-level context.

3: Recontextualizing Tasks: Reorganizing Cognitive Processes

It is important to demonstrate that changes in contextualization of tasks can be engineered to make a difference in task performance. Before progressing to evidence from existing curricula, we turn briefly to existing lines of research at a level more or less equivalent to a lesson, problem, or task. The experimental work that will be called to mind by these examples is usually referenced in arguments demonstrating that young children are not as cognitively limited as had been claimed on the basis of more normative experimental procedures or in arguments demonstrating that older people are not able to do the advanced cognitive work one might expect, unless the conditions are modified (Cole & Means, 1981; Gelman, 1978). In this review, the cases are intended to demonstrate that contexts for cognitive tasks can be changed and that such changes can produce a change in ease of learning. Having shown evidence for this claim in cognitive research conditions, we will explore its fate when embodied in the curriculum.

Research Evidence

Istomina (1975) compared the performance of preschool children on a test-like version of a free recall task and the same task embedded in a role-playing game of being sent to a make-believe store for a list of items. In both versions, the child wants to do what the experimenter tells him to do—he tries to remember and reproduce the list of words. Activation of the 4- and 5-year-olds' still-crude memorizing operations was greatly facilitated by the play situation. They learned and remembered more in the *same* amount of instructional time.

Young children have long been thought deficient in their ability to keep the location of objects in mind. The basis for this conclusion was decades of research on delayed responses: an object is hidden in one of several boxes, and children are required to search for it several seconds or a few minutes later. DeLoache and Brown (1979) repeated this experiment with 2- and 3-year-old children in their homes. Instead of a piece of candy, children's favorite toys were hidden under a piece of furniture. Under these conditions, children would remember the location of the hidden object for at least 24 hours, the longest interval tested.

Margaret Donaldson (1978) and her students addressed the presumed inability of small children to take account of another person's visual point of view. In the original research on the problem by Piaget and Inhelder (1975), children were required to identify pictures representing a different view of a model of three mountains. Not until age 10 or 11 does this task become accessible to children.

However, perspective taking ability has been shown to be present for recruitment into problem solving by very young children in the right circumstances. Donaldson arranged for the model to represent toy children hiding from a toy policeman. The model was so arranged that only by taking the policeman's point of view could the child-subjects know where the toy children should hide. Four- to five-year-olds succeeded at this problem even when they had to coordinate the points of view of two policemen, whose views of the scene were different from their own. Thus, when the purpose of such perspective taking was made accessible to the youngsters, they managed to succeed at tasks hitherto thought beyond their capacity.

Recontextualizing in a Curriculum

The potential for recontextualizing tasks does not have to be limited to classical problems in the developmental literature or to very young children. Beneficial effects of recontextualizations have been demonstrated to occur with older populations (especially university students) who were trying to achieve solutions to syllogistic reasoning problems (D'Andrade, 1981; Johnson-Laird, Legrenzi, & Sonino Legrenzi, 1972). Rather than review these results, which are widely known and have entered the main body of scholarship involving cognitive factors in education, we will review two projects that could provide for recontextualization of tasks outside of experimental conditions and in the educational domains especially relevant to this report—science and computer technology.

The computer program Dynatrack (diSessa, 1982, 1984) can play a role in arranging for the recontextualization of physics learning by providing for its embedding in a larger activity. In high school or college sciences courses, students are expected to learn that there are physical laws governing the motion of physical bodies. In Dynatrack, the student enters a microworld where some physical laws do not hold. It is a very simple program. The player is represented on the screen by a small object; the goal is to move around a circular track; at first, the player, not applying the proper physical laws, loses control and crashes into the barriers of the track; eventually, the player's actions become coordinated with the particular physics of the Dynatrack world.

Playing Dynatrack by itself is not the recontextualization; rather, including Dynatrack in a curriculum aimed at teaching and learning physical laws is the recontextualization. If experience with Dynatrack is organized so that observations about the experience in the special world can be related to observations about the ordinary world we live in, as well as to the experience of learning physical laws and the computation of their explanation, then experience with Dynatrack can be an activity that provides for the recontextualization of knowledge in a standard physics curriculum.

A great deal of recent work in cognitive science (e.g., Gentner & Stevens, 1983) demonstrates that the mental representation of problems held by experts in a domain like physics appears to be holistic and to involve qualitative reasoning; the final specific computation is simply a verification of the answer. Experts do not start their work on problems with computational procedures, but beginners and low performers do attempt to start with computations. The problem for the educator is to discover how to provide a beginner with something like an expert's viewpoint, a holistic framework where qualitative reasoning can be supported. Dynatrack, and programs like it, can contribute to providing experience with the world of physics that can complement and provide a productive organizational framework for the procedural steps that students are taught in current curricula (Heller & Reif, 1984).

A final example, from Japan, involves a book for the general public. The *LOGO Handbook* (Miyake, Honda, Tanaka, & Nakano, 1984) is intended for adults learning LOGO, a programming language. The six chapters cover the crucial aspects of the language; the book, and the approach to teaching/learning, mixes LOGO with rich reference to life in Japan.

In the first chapter, a well-known and loved poet's work is analyzed, and learners have their initial LOGO lesson while mimicking a part of the process of juxtaposition that the poet uses to create his art. The learner begins with a full and interesting program, focusing on characteristics especially important about LOGO, i.e., in contrast to first learning "Forward" (as most LOGO curricula encourage), these students learn "First," "Last," "But first," etc., the commands that embody the sophisticated nature of the LOGO language. The book helps to create an activity system that mixes poetry and the programming language, creating an environment for learning very advanced features of the programming language very early in the instructional sequence.

Another example of the richly contextualized learning approach is apparent in the treatment of recursion. Here, a narrative about an everyday event is told in two versions, and the learner can create dialogue for a scene in each narrative with a LOGO program. The two LOGO programs that are produced provide a minimally contrasted set, in which tail and center recursion are the elements contrasted. The basic schema for the story is the opening of an after-school school (a *juku*) for learning English; a person is trying to teach but must also answer the phone in case there are new pupils wishing to enroll. In one version of the story, a calm teacher asks a question, gets interrupted by a phone call, gets the answer from a student and evaluates it, and then asks the next student the same question. Tail recursion is used in the program for this version of the narrative. In the other version of the story, a very opposite sort of teacher is the lead character; this teacher asks a question, gets interrupted by a phone call, asks another student the question and so on, until at the end there is a raft of student answers, in the opposite order from which they occurred in the prior story. The program for this version uses center recursion. Again, the focus on a very important feature of the task domain (recursion) is embedded in a context that is rich with cultural understanding and, here, whimsy.

Casting Doubt on the Assumed Contextualization

The sophistication of the cognitive activities promoted by these unusual experimental and instructional procedures cannot be denied; moreover they are precisely the "basic cognitive activities" (holding information in memory, building structured representations for later use, comparing perspectives, learning physics, learning programming) that are relevant to achieving basic technological literacy, the central concern of this review. Evidence indicates that changes in the *context* of the logical task structure change the cognitive task itself, making available otherwise untapped cognitive resources which subjects/students can bring to researchers/educators for purposes of instruction.

Research on the educational status quo may show that some things are very hard to learn (cf. Pea & Kurland, 1984, regarding recursion in LOGO) or that some things take a long time to learn; but, when such research relies on the assumed normative contextualization of the tasks, it may be seriously misrepresenting the problem. The work described above suggests that a fundamental way of changing the requirements for success on a particular task is to *recontextualize* the task as presented to, and understood by, the learner. In all the sample cases, the subject is initially presented with the activity—the whole task—embedded in, contextualized as part of, some larger activity. For the subjects themselves, the recontextualization involves familiar scripts and human intentions. Aspects of the concentric circles in Figure 1 influence how the task is perceived by the learner and/or the motivation with which he/she tackles it.

We do not expect that recontextualization of academic tasks and of assessment will make the problems of education disappear. Rather, we expect that innovation at this level of the context, in concert with innovations in the social organization of lessons and in school-community linkages, will provide educators with more fertile ground for effective educational action. A recontextualized task can give the instructor something more to take advantage of in instructional sequences.

4 • The Classroom Level

A great deal of research is relevant to ways in which reorganization of classrooms changes the quality of educational performance at the level of the lesson. After reviewing the factors producing increased effective learning time and student achievement, Harnischfeger and Wiley (1981) summarized their conclusions as follows (with numbers added for easier subsequent reference):

> There are only four ways to increase achievement. One (1) is via a reduction in time needed to learn. All of the others depend upon increasing active learning time. These latter three routes consist of:
>
> (2)—increasing the total amount of time which is allocated to learning,
>
> (3)—increasing the portion of that allocated time which is actually allowed for learning, and
>
> (4)—increasing the amount of this allowed time which pupils actively devote to learning.
>
> The last of these routes (4) is solely influenced by a teacher's effectiveness in monitoring and maintaining pupil pursuits via surveillance and teaching interchanges with pupils, which motivate or coerce them to spend more of their time actively learning. Increasing the proportion of allocated time which is actually allowed or used for learning (3), on the other hand, is primarily achievable via managerial improvements, both intra- and inter-task. And direct increases in allocated time (2) are entirely the outcomes of procedural and curricular policies of districts and schools. (Harnischfeger & Wiley, 1981, pp. 30-31)

Of these four factors, the first can be related to the "context rich" instruction/assessment described in section 3 above; the recontextualization strategy might as easily be described as increasing the efficiency of the teaching/learning context as reducing the time needed to learn. The second factor is at the level of the school and beyond and will be addressed in subsequent sections. Recent developments in the implementation of time-on-task research have understandably concentrated on the third factor, managerial improvements, focused on categories such as classroom discipline and decreasing interruptions, because they can be quantified within the standard, context-free framework. (Cf. Purkey & Smith, 1983, for a critical review of the spate of studies on effective schools showing the pervasiveness of managerial improvements in another aspect of educational research.) This section is about the fourth strategy, increasing the amount of active, engaged learning time.

Manipulating Class Size

One of the obvious ways to change the management climate of a classroom is to manipulate class size. *More is learned in smaller classes.* Based on the exhaustive study of data on nearly 900,000 students, Glass and Smith (1978) concluded that student achievement increases as class size decreases, especially when class size goes below 20.

The policy implication would appear clear: decree that all classes will be smaller than 20 students and more effective education will result. Although there may be no objections to such a solution in principle, in practice it means money, a lot of money, and probably more space as well. Since all sectors of society are being asked to spend less public money, not more, giant increments of funds to produce smaller classes are not likely. The challenge for research is to point the way to reorganizing the process of education that remains more or less within spending constraints, as they vary with the political and economic climate. Currently that means coming up with suggestions for change that do not entail greatly enlarged budgets—an almost free lunch.

Keeping Class Size Constant, But Manipulating Organization

The Time To Learn study conducted for NIE pinpoints the classroom conditions needed if we are going to improve student achievement by increasing active learning time.

> *More substantive interaction between students and an instructor is associated with higher levels of student engagement.* Substantive interaction between teachers and students consisted of presentation of information on academic content, monitoring of work, and feedback about performance. Most student-teacher interaction took place in a group setting, with only a small part of such interaction occurring during seatwork as one-to-one "tutoring." Students who spent more time in a group setting had higher rates of engagement. . . . Engagement rates were especially low when students spent two-thirds or more of their time in seatwork and had little interaction with the instructor. (Fisher et al., 1980, pp. 21-22)

The conclusion to be drawn from Fisher et al.'s work would seem to be clear: Classes based on seatwork do not permit the right kind of "substantial interchanges" crucial to effective learning time. The "obvious" answer is to break the class into smaller groups for instruction (perhaps using paraprofessionals, parent volunteers, or older students as group leaders, thereby increasing student-instructor interaction and increasing the quality of the activity of children outside the teacher-led small group). This obvious solution, however, is fraught with problems about how to divide students into groups and how to organize all the groups' instructional activities effectively.

A large body of research on activity organization focuses on the effects of different principles of grouping for instructional purposes (see Peterson, Wilkinson, Spinelli, & Swing, 1984, for a comprehensive discussion of this literature). The most common basis for instructional grouping is student ability and tracking.

Tracking and Ability Grouping

Tracking refers most often to grouping by ability in separate classrooms; this option is frequently found at the secondary level (Alexander & McDill, 1976; Good & Marshall, 1984; Metz, 1978; Persell, 1977; Rosenbaum, 1976). The more frequent strategy adopted at the elementary level is separate ability groups within a single classroom (Austin & Morrison, 1963; Barr, 1975; Hallinan & Sorensen, 1983). With respect to *within* class subgroup formation, ability grouping in teacher-led instructional activities occurs most commonly (Good & Stipek, 1983).

Cicourel and Mehan (1985) summarized recent research on ability grouping:

> There have been many accounts of differential treatment in ability groups reported by researchers who have examined classroom interaction closely (e.g., Henry, 1965; Rist, 1970; Cicourel et al., 1974; Eder, 1981; Gumperz & Heramsichuk, 1975; Michaels, 1981; Wilcox, 1982). These researchers report that the *distribution* of students to high, middle, and low ability groups seems to be related to characteristics associated with SES: Children from low income or one parent households, or from families with an unemployed worker, are more likely to be assigned to low ability groups.
>
> The work by Cicourel and Kitsuse (1963) suggests that children from low income families with low grades and low test scores would always be tracked into lower groups, whereas children from middle income families or higher income families with low grades and low test scores could be tracked higher, particularly because of parental intervention. The more telling finding by Cicourel and Kitsuse is that children from low income families with adequate test scores and low grades were placed in a lower group, while the corresponding children from middle income families were placed in a middle level track. (Cicourel & Mehan, 1985, pp. 18-19)

Group placement has been shown to be stable over time (once in the low group, it is hard to get out) and to impact differentially high and low group students.

A range of studies consistently and robustly document the detrimental effect of ability grouping within classrooms on students who are placed in average and low ability groups. Good and Marshall (1984) document "a consistent pattern of deprivation for low students in schools that practice tracking." With respect to instructional processes and student motivation, behavior, and achievement, there is not a single observational study that shows positive consequences for low-track students. Differences in instruction across high and low reading groups, both with respect to content and the quality of interaction, have been found to "sustain the poor performance of slower students and to increase the disparity between the two groups" (Good & Marshall, 1984, p. 18; cf. McDermott, 1976). Inappropriate grouping may amplify relatively minor differences at the beginning of first grade into major differences in later grades (Hallinan & Sorensen, 1984).

Persell (1977, p. 92), in a review of 217 ability grouping studies, found that "there is a slight trend toward improving the achievement of high ability groups but that is offset by substantial losses by the average and low groups." There could be more subtle effects from an abolishment of tracking on high achievers based on a change in curriculum goals amounting to lowered standards (see Resnick & Resnick, 1977). This gets to the nub of the issue: crudely, and we believe incorrectly, put, Should the high groups be sacrificed to the low groups or vice versa? The error in that crude question is a dual simplification: (1) the acceptance of a context-independent evaluation of high and low, as if recontextualization of teaching and assessment procedures would not reorganize such evaluation (see section 3 above); and (2) the assumption that "tracking" and "not tracking" are the only alternatives for classroom organization.

Alternative Classroom Organizing Principles

An alternative to tracking, which divides classes according to a unidimensional criterion of prior achievement levels, is to create instructional groups in which the pattern of interactions that assemble instruction is *qualitatively* reorganized.

Stodolsky (1984) provided a typology of face-to-face instructional groups, all of which contain less than the whole class as members (see Table 1). She argued that there is a major contrast (in interactional processes and outcome) between teacher-led groups (prototypically the tracked reading groups which are relatively heterogeneous with respect to other academic achievement) and what she called "peer instructional-work-groups."

On the basis of a review of a great many relevant studies of peer work groups, Stodolsky concluded,

> The results of these studies showed that children working together produced problem solutions characterized by higher cognitive levels of response than individual children could produce. The researchers (Skon, Johnson & Johnson, 1981, p. 84) suggest that "the academic discussion within cooperative learning groups promotes the discovery of higher quality reasoning strategies."

The kinds of lesson organization referred to by Stodolsky were common characteristics of the most innovative curricula in mathematics, science, and technology education introduced during the 1960s. These curricula call for breaking large classes into small working groups in the manner of cooperative work groups. They also require flexible support activities by teachers, which take advantage of group dynamics as well as a variety of school, classroom, and community factors. A number of successful science and mathematics curricula have developed quite extensive support materials that are multimedia. Among programs of high merit we can include:

The *Elementary Science Study Curriculum* developed by Education Development Center, Inc. (EDC) in Cambridge, Massachusetts.

The *Science Curriculum Improvement Study* from Lawrence Hall, Berkeley.

Table 1

Typology of Classroom Organizing Principles

TEACHER-LED GROUPS	PEER WORK-GROUPS
Subset of Class–Ability Grouped Expectations for performance uniform for each member of group Evaluation directed to individuals Little or no peer interaction expected Teacher controls distribution of child contributions-performances	**Completely Cooperative** Common end or goal Common means and activities All members expected to interact-contribute Joint product evaluated
Subset of Class–Not Ability Grouped Expectations for performance usually uniform for each member of the group Evaluation directed to individuals Little or no peer interaction expected Teacher controls distribution of child contributions-performances	**Cooperative** Common end or goal Some divided activities or tasks All members expected to interact-contribute Joint product evaluated
	Helping Obligatory Individual goals Interaction required, helping from any member to any other member Each individual evaluated
	Helping Permitted Individual goals Interaction as desired from any member to any member Each individual evaluated
	Peer Tutoring Tutee's goals Help in one direction from tutor to tutee Tutee work evaluated

NOTE. From "Frameworks for Studying Instructional Processes in Peer Work Groups" by Susan Stodolsky in *The Social Context of Instruction: Group Organization and Group Processes* (p. 114) edited by P. L. Peterson, L. C. Wilkinson, and M. Hallinan, Orlando: Academic Press. Copyright 1984 by the Regents of the University of Wisconsin System.

The *Active Learning Approach to Mathematics Curriculum* developed in England by Biggs and others and embodied in a book by Biggs and MacLean, *Freedom To Learn*, published by Addison-Wesley, 1969.

These curricula are generally child and activity centered. They attempt to make explicit the principles that teachers might use to implement such curricula.

They also excel in providing teachers with a wide range of do-it-yourself hints using readily available materials. What they do not provide are any explicit principles-in-practice for coordinating classroom activities over a whole school day or a large segment of the curriculum, maintaining discipline, and fitting the diversity of entering skills of students into the diversity called for by the curriculum. These curricula were undertaken by educators and scientists from a variety of backgrounds, and evaluation of them runs into the many problems of design and measurement that our interdisciplinary committee recognized. Nevertheless, with some temporal distance, the overall picture is positive. In his meta-analysis of evaluations of the new science curricula of the 1960s, Kyle (1984) concluded that:

> Recent research syntheses demonstrate the effectiveness of the hands-on, inquiry-oriented science curricula developed during the 1960s and early 1970s. Evidence shows that students in such courses had enhanced attitudes toward science and scientists; enhanced higher-level intellectual skills such as critical thinking, analytical thinking, problem solving, creativity, and process skills; as well as, a better understanding of scientific concepts. Inquiry-oriented science courses also enhanced student performance in language arts, mathematics, social studies skills, and communication skills. (Kyle, 1984, p. 21)

Despite this conclusion, there has been little uptake that can be seen in today's science classes. Kyle (1984) cited Yager's synthesis of the crisis in science education:

> 1. Nearly all science teachers (90%) emphasize goals for school science that are directed only toward preparing students for the next academic level (for further formal study of science).
>
> 2. Over 90% of all science teachers use a textbook 95% of the time; hence the textbook becomes the course outline, the framework, the parameters for students' experience, testing, and world view of science.
>
> 3. There is virtually no evidence of science being learned by direct experience.
>
> 4. Nearly all science teachers "present" science via lectures and/or question-and-answer techniques; such lectures and question/answer periods are based upon the information that exists in textbooks chosen.
>
> 5. Over 90% of the science teachers view their goals for teaching in connection with specific content; further, these goals are static, i.e., seldom changing, givens. (Kyle, 1984, p. 7)

There have been many attempts at explaining this state of affairs (see Holdzkom & Lutz, 1984, for good summaries). What they boil down to is that the new way of doing things required extra resources of teaching time and preparation time and presented difficulties in obtaining the proper logistic resources on site. Extra effort is shown by a few teachers and supported by a few communities. But by and large, the required changes have been too much trouble.

It appears that we are faced with a paradox. Small-group, student-involved or led, hands-on science activity is successful, yet people are doing the opposite.

Complications in Cooperative Student Groupings

The paradox involved in the failure of successful curriculum interventions that change the context of instruction indicates that significant barriers arise from our poor understanding of the dynamics of student-centered groups and the resources necessary to replicate success stories on a routine basis. However, the shortcomings of instruction based on ability grouping make it worthwhile to pursue alternatives.

Two sets of consistent findings have emerged: (1) teacher-led ability grouped lessons negatively impact low-grouped students (where minority and poor students are disproportionately represented) and (2) cooperative, mixed ability group processes genuinely enhance learning and cognitive development *in some circumstances.* (See also Sharan, Kussell, Hertz-Lazarowitz, Bejarano, Ravis, & Sharan, 1984; Slavin, 1978). A major research need is to specify the circumstances that make cooperative heterogeneous groups work and be maintained beyond the experimental phase.

It is clear that the care with which tasks are designed and materials prepared for cooperative groupings is of crucial import. Well-designed tasks and appropriate resources are even more important than they are in teacher-led groups, precisely *because* the teacher is only intermittently available as a leading coordinating resource.

A less obvious problem is pointed out vividly in Cohen's (1984) research: Learning of curriculum content in a peer work group is positively related to the frequency of interaction within the group, and frequency of interaction in turn is correlated with social status in the classroom. In more blunt terms, small groups can be one more setting in which the rich get richer, and the poor—minorities or women—lose out; differential treatment can come as readily from peers as from the teacher.

> The use of heterogeneous peer groupings in the classroom is like a two-edged sword. Talking and working together clearly has favorable effects on learning, especially conceptual learning. In this study, children who were seen as highly problematic by their teachers showed excellent learning gains. . . . Given a strong curriculum, this model of instruction is a viable alternative to the common pattern of ability grouping. . . .

> However, heterogeneous groups also have distinctly negative effects. Whenever the instructional grouping is heterogeneous and the students are put into the position of using each other as resources for learning, status characteristics will become salient and relevant to the interaction. As a result, higher status students will have higher rates of participation and influence. These differences in participation and influence are often accepted as inevitable consequences of individual differences in ability. In contrast, I have argued in this chapter that they can also be seen as a product of the status structure of the classroom.
>
> The advantage of seeing behavior partly as a consequence of status instead of a consequence of individual differences is that it frees the practitioner and researcher from having to accept the inevitable. Instead, it is possible to manipulate the social situation so as to weaken the effects of status. (Cohen, 1984, p. 18)

Fortunately, there is research that shows that leadership ability in these work groups is not an enduring individual "trait" but rather a temporary "state" influenced by the nature of the task and group composition. Cohen has herself successfully shifted the interaction patterns of previously low status students by giving them prior training in skills that are not culturally stereotyped—e.g., teaching a black student who has low status in the classroom how to build a transistor radio, not how to execute a fancy basketball maneuver, and then arranging for that student to teach others in the group.

It is reasonable to question whether such status manipulation can occur outside the confines of experimental conditions. A natural, nonexperimental version of the same status shift can be seen in Kagan's (1981) research: By manipulating the activities of the individuals involved in peer groups, it is possible to change their perceived status evaluations and bring about positive educational outcomes.

Roles and status within the cooperative task environment can also account for differential learning among the students involved. Role alternation is an important factor: the performance of participants who exchange roles appears to exceed those of individuals who work in a fixed role. The "reciprocal reading" technique developed by Brown and Palincsar (1982) is an example of a curriculum manipulative in a school domain that involves adults and children in cooperative role alternation.

Existing research suggests the efficacy of student activity groups to enhance learning; some progress has been made toward specifying the characteristics that are necessary for successful use of such groups. However, much research remains to be done before we understand how to make these sorts of groups successful in multiethnic classrooms around a range of mathematics and science tasks.

Linguistic and Cultural Factors

The research reviewed below shows that reorganization of lesson formats to make them sensitive to linguistic and cultural variations can promote educational excellence. But linguistic and cultural variations can also be a barrier to achievement if measures are not taken to integrate them properly into students' activity.

Erickson and Mohatt (1982) worked among the Odawa in Canada. Their successful educational strategy was based on discourse modes prevalent in the children's community (Phillips, 1972). The analysis, based on ethnographic techniques, was specific enough to warrant treatment-specific claims about the discourse strategy's effect.

The phenomenon that Erickson and Mohatt addressed was the apparent passivity and silence of Native American students in regular classrooms that had been studied by Phillips. Very different modes of classroom discourse feel comfortable to Anglo and Native American children living in the northwestern United States (Phillips, 1972).

> The notion of a single individual being structurally set apart from all others, in anything other than an observer role, and yet still a part

> of the group organization, is one that Indian children probably encounter for the first time in school. (p. 391)

Native American children who find themselves with an Anglo teacher encounter a single, powerful person regulating the behavior of many others. In these communicative circumstances they adopt the observer role that they know to be appropriate. Like good observers, they are quiet. They also adhere to the rule that it is not acceptable to single out individuals for praise or censure on a public occasion, so they experience difficulty when singled out for evaluation by the teacher. The result is what Erickson and Mohatt call the "often reported phenomenon of the 'silent Indian child' in the classroom." Their behavior is inappropriate to the standard mode of instruction in which the teacher acts as a "switchboard operator" who allocates speaking turns, calls on individual children, expects active participation, and evaluates each child's turn at contributing to the lesson.

Erickson and Mohatt showed that it is possible to construct rules of participation in the classroom which are a functional blend of the Anglo school curriculum and Native American discourse styles and which make the classroom run much more smoothly. These patterns seemed to be learnable; an Anglo teacher was observed to change his participant structures over the course of the school year in the direction of those structures common to the Odawa.

Another and even more important set of studies also transforms classroom settings by taking students' language and culture into account. The best documented is the decade-long research and development effort at the Kamehameha Early Education Program (KEEP) in Hawaii (see Au & Kawakami, 1984).

The KEEP program provides an example of how using knowledge of students' language and culture can be used to help students in learning to read. A notion central to KEEP is that of cultural compatibility. This involves creating classroom settings that permit students to apply language and task-completion skills already in their repertoire. The largest population of the KEEP program are children of Polynesian Hawaiian ancestry. Two examples of culturally compatible educational practice illustrate the principle of cultural compatibility.

The first is known as the open door policy. This feature builds on young Hawaiian children's experiences in taking on major responsibilities for the smooth functioning of their households. Thus, the teacher allows them to assume a similar level of responsibility for setting up the many learning centers used in the classroom. A second example is the use of talk-story-like participation structure in small-group reading lessons. Talk-story is a common speech event in Hawaiian culture, characterized by overlapping speech and cooperative production of narrative by two speakers. In the reading lesson the teacher allows the children to discuss text ideas using rules for speaking and turn-taking similar to those in talk-story.

The effectiveness of the KEEP program in bringing about the improvement in Hawaiian children's reading (Tharp, 1982) suggests that cultural compatibility in instruction can indeed help minority students prosper in public school settings. To test the hypothesis that cultural compatibility was a critical feature of KEEP's success, Jordan, Tharp, and Vogt (1985) attempted to implement aspects of the KEEP program in a classroom of Navajo Indian students. These efforts required adjustments in the KEEP program to make it compatible with the culture of this different group of students. For example, Navajo students have experience with community speech events where longer individual speaking turns are expected than in talk-story. Thus, in giving small-group reading lessons, the teacher encouraged the students to speak following these norms. The findings of this project suggest that effective educational programs may be built on the wide variety of cultural values and language abilities shown by minority students. What should be transferable are principled means of developing culturally and linguistically compatible educational innovations.

A third example of cultural and linguistic compatibility is Heath's (1982a, 1982b) ethnographic research and work with teachers in a black community that she calls Trackton in the southeastern U.S. This work will be discussed more fully in the later section on home-school relationships. Here we want to report changes in classroom practice that resulted from it.

When the teachers complained that children did not participate in lessons, Heath helped them understand what she had learned from five years of ethnographic field work in the Trackton community. For example, the children were not used to known-answer questions about the labels and attributes of objects and events; as one third-grade boy complained, "Ain't nobody can talk about things bein' about theirselves." She then worked with the teachers to try out changes in their classrooms.

These changes consisted of the following sequence:

> 1. Start with familiar content, and with familiar kinds of talk about that content;
>
> 2. Go on to new kinds of talk, still about the familiar content, and provide peer models, available for rehearing on audio cassettes;
>
> 3. Provide opportunities for the Trackton children to practice the new kinds of talk, first out of the public arena and also on tape, and then in actual lessons;
>
> 4. Finally, talk with the children about talk itself.

Literacy was the focus of a fourth example involving Hispanic children in the southwest. In a series of related studies, Moll, Diaz, Estrada, and Lopes (1980) and Moll and S. Diaz (in press) analyzed reading lessons. The children were observed in reading lessons in English and in Spanish. The analysis of these several settings revealed two important findings. In the Spanish reading lessons, all of the children were performing at grade level; in the English-only classroom, in contrast, these same students were engaged in reading lessons far below grade level. The emphasis of the English lessons was on decoding. This instructional strategy was in marked contrast to the one in the Spanish classroom which emphasized comprehension, even with the lowest ability groups.

Moll and Diaz concluded that the students had skills for reading which were seriously underestimated and were not being effectively taken advantage of when they were reading in English. The teacher was aiming the lessons at the students' oral English skills and not their reading skills. English pronunciation problems were being mistaken for decoding problems; the demands for oral performance by the children, coupled with the teacher's inability to assess evidence of comprehension when the children spoke in Spanish, caused the English lessons to focus exclusively on decoding and to be limited to subject matter far below the children's abilities to comprehend.

In a second study, Moll & Diaz (in press) designed a four-phase training experiment which used the students' native-language skills as a resource for their learning to read in English. In the first phase of the experiment, the teacher who ordinarily taught English reading conducted a regular reading lesson. Although the students were fourth graders, the level of the reader used in the lesson was first grade; the lesson was conducted entirely in English (the teacher was monolingual). The students had great difficulty getting through the lesson and, on the basis of their oral discourse, displayed poor understanding of the story.

In the second phase of the experiment, immediately following the first, one of the researchers (a fluent bilingual) took the teacher's place and asked comprehension questions about the story in Spanish. It was evident that the students had completely understood the story—a marked contrast to their performance in English.

The third phase was an intervention in a "bilingual mode" using the regular fourth-grade English text. A researcher read the text aloud while the students followed along silently. A discussion of the reading followed to see whether the students had a general understanding of the story. Students did have a fair grasp of the text displayed by their (mostly Spanish) discussion of the story. Apparently, students understood spoken English relatively well but had problems with oral expression. They understood grade-level material when it was read to them in English.

The fourth phase allowed the students to apply the reading skills from their native language (which were at grade level) to a new English text, also at grade level. The students were assigned a story to read at home (a familiar practice from their native-language class) and asked to come prepared to discuss it and answer questions the next day. On the following day, a general discussion of the story was conducted bilingually. The researcher asked questions or raised points for discussion in English or Spanish, and the students usually responded in Spanish. After a general discussion the students were asked to answer the questions at the end of the textbook story in any language mix they chose. The students correctly answered the majority of the questions, even those requiring that the reader make inferences about topics that were not directly discussed in the story. Apparently, the students could display competence on grade-level material when the practices and language from the Spanish classroom were applied to English reading. From one point of view it can be said that this intervention changed the level of the children's performance from grade 1 to grade 4 in the time span of a week.

Moll and Diaz followed their experiment with an informal investigation of the potential for the intervention to be used over a longer period of time. When the same children were taught in the bilingual mode using English text appropriate for the Spanish reading level by a bilingual who was a regular classroom teacher, the children continued to improve and, interestingly, showed more and more preference for carrying on the discussion of the English text in the English language. Serendipitously, while the intervention was designed to minimize the negative impact of the children's inadequate oral English skills on their learning to read English, it provided impetus and practice time for oral English for the children.

The Moll and Diaz bilingual reorganization of reading lessons, which permits students to rely on and display reading skills acquired in their native language, can promote the development of advanced reading skills in English. Extended work with the students demonstrated that the advanced reading level could be maintained over time and could be built on for further advances. Such a reorganization capitalizes on the strong base of literacy skills developed in the native language to keep students with a limited-English proficiency performing at grade level in English.

These examples demonstrate that language- and culture-sensitive pedagogy can make a difference when it is possible to be explicit about cultural and language patterns and when there is not much linguistic and cultural heterogeneity in the classroom. In each case, it is important to note that culture-sensitive does not mean a focus on the traditional arts, foods, and folklore of a group. Instead culture-sensitive means sensitivity to "relatively subtle aspects of interactional etiquettes [that] are likely to go unrecognized by nonminority teachers" (Erickson & Mohatt, 1982, pp. 166-167).

Classroom Context and Generality

The research to which we have paid particular attention at the classroom level of the concentric rings of context focuses on the elementary level. While the earlier section on the recontextualization of the task and later sections on the school and community levels redress this imbalance, a question should be raised about the dependence of effective classroom systems on the age of the children involved. Why not focus on studies about high schools?

A simple answer is that there is little such research. The reason for the dearth of detailed work on secondary school students deserves further comment because it touches both on problems of methodology and on strategies for productive pedagogical intervention. The methodological problem is closely connected with the age-related characteristics of secondary school students. They are adolescents. They have far greater freedom from adult control in their nonschool lives than do elementary school children. As a consequence, there is relatively little fine-grained ethnographic work with people this age. Yet the interesting work on the intricacies of alternate grouping strategies and culture-sensitive curricula begins with the detailed understanding of the students' ordinary life experiences that such ethnographic work provides. Of the available work with adolescents, little has a pedagogical focus relevant to effective strategies in classrooms. Just as adolescents, particularly those with a disappointing school history, find nonclassroom contexts much more seductive than those involving school work, so, it appears, do researchers who focus on adolescents (e.g., Agar, 1975; Labov, 1972).

A second reason for the relatively scant data on alternative contexts of instruction among adolescents is the strong intuition that if children seriously underachieve in the later elementary school years they face hardships in secondary school that will be very difficult to overcome. On the other hand, if students could be helped to complete the elementary years with a strong foundation in literacy and a positive orientation to school-learning, the schools could more effectively compete with the other (noneducational) activity settings that are made all the more seductive when adolescents have to compare them with the unpleasantness of chronic failure in school.

5: Computers' Impact on the Context of Instruction

It is time to introduce a factor into the mix of considerations about reorganizing classroom lessons that has attracted a great deal of recent attention: The promise of computers to deliver us from the problems facing our educational system. To keep the scope of our discussion within manageable bounds, we will distinguish our own treatment of computer technology and education sharply from those discussions that focus on the computer as a direct educational tool (diSessa, 1984). Because of our focus on context factors, we will not review the literature on educational microworlds, computer-aided instructional systems (CAI), or the teaching of programming languages (Hawkins & Sheingold, 1983; Papert, 1980). Instead we will concentrate on the indirect impact of computers on education through their power to redefine the contexts in which education occurs at the level of the classroom, the school, and school-community relations.

The Current Situation

There can be little doubt that, whatever their potential for educational benefit, as computers are currently employed in America's classrooms they are making the position of minorities and women relatively worse with respect to the Anglo/male norms that are used in such comparisons. A number of studies (CSOS, 1983-84) show that:

- more computers are being placed in the hands of middle and upper class children than poor children;

- when computers are placed in the schools of poor children they are used for rote drill and practice instead of the "cognitive enrichment" that they provide for middle and upper class students; and

- female students have less involvement than male students with computers in schools, irrespective of class or ethnicity.

We believe that the reasons for this situation run deep in our society's beliefs about (a) the mental characteristics of the populations involved and (b) the uses to which computers can be put. Especially important in this regard is an educational ideology which asserts that children must learn the basics before proceeding to higher order problems (reminiscent of Jensen's, 1973, notion that there is a rote Level 1 mode of learning that precedes a higher order Level 2). Hence, for children who are "behind," applying this ideology would keep them in contexts focusing on rote skills. Modern research in learning and development have adopted more sophisticated systems approaches that highlight the heterogeneity in developing systems (Gardner, 1983; Gould, 1976; and many others). This suggests that experiences in Level 2 contexts should not be held off, pending a catching up on Level 1 skills. A major contribution of computer technologies is that they can create new media for overcoming this false Level 1/Level 2 distinction, in spite of the current pattern of utilization in which computer use exacerbates the problem of the false distinction.

Computers appear to be a promising tool for creating mixed systems to cope with the complexity of modern societies by coordinating interactions in a new way. There are a great many complex issues at stake when guessing about the future, as everyone has rushed to do with computers and modern telecommunications devices. Yet, in the educational arena, countries around the world are agreed on the necessity for greatly expanded student capacities to make use of the potentials in computers without fully understanding what their decisions entail. Especially important, and explored below, are questions of how the introduction of new technologies affects the operation of classroom systems, how it can be related to promoting equality of education for women and minorities, and how new technologies can promote "leaks" between the concentric circles of our embedded contexts diagram, i.e., linkages among the contexts relevant to education.

Classroom Organization and Computers

To make clear the special relevance of computers for reordering the contexts of education (and thereby, the motivational structure of instruction), we will contrast two metaphors for computer-student interaction. The first assumes that the computer is an agent, operating as a "partner in dialogue." This view implies that the student-computer system can be viewed as an analogue to the student-teacher system with the computer replacing the teacher. Within the framework provided by this perspective, it is important to look at the computer's potential for providing structured hints, well-timed feedback, and a wealth of factual knowledge. It is this metaphor that underlies the bulk of research on computers and education at the present time. It leads naturally to dreams of a "teacher-proof" curriculum.

A second metaphor, the one that will undergird this discussion, is of the computer as a "medium," not replacing people, but reorganizing interactions among people, creating new environments in which children can be educated and grow by discovering and gaining access to the world around them. This metaphor emphasizes the potential of computers for reorganizing instruction within the classroom and for making possible the extension of education beyond the classroom. It involves teachers in a new system of possibilities and social demands in the education of their students. It often challenges teachers' prior learning, requiring the acquisition of new skills (and extra time on their task of staying abreast of their students). As we shall see, successful introducers of computers into classrooms are as much orchestrators of their students' activities as they are occupants of the usual role in a teacher-led group. Certainly other educational innovations (e.g., cooperative grouping strategies, activity-based curricula for science and mathematics) have called for similar role redefinitions for teachers. However, in those other cases role specifications were an overt and articulated element of the innovation; with the introduction of computers into classrooms, the specification of the teacher's role is easy to overlook, but we believe it is essential to arranging for the attainment of learning goals. Effective computer-using teachers are "Adaptive Experts" (Hatano & Kokima, 1984) at the process of teaching/learning on computers. Through proper combinations of software, hardware, and social support, systems of clear excellence can be obtained for a wide variety of students. But the obstacles to satisfying the hopes for clear success are formidable.

Shavelson, Winkler, Stasz, Feibel, Robyn, & Shaha (1984) examined—through interviews and observation—the patterns of computer use of 60 elementary and secondary teachers who had been nominated as exemplary users in mathematics and science instruction. They defined instructional computer use as

> the appropriate integration of microcomputer-based learning activities with teachers' instructional goals and with the ongoing curriculum, which changes and improves on the basis of feedback that indicates whether desired outcomes are achieved (Shavelson et al., 1984, p. vi).

Based on this definition, they characterized teachers' microcomputer-based instruction according to 16 variables. Four clusters, or patterns of use, emerged from the analysis. Cluster 1, called orchestration, represented the widest variety of instructional applications closely linked to regular curricular activities.

> Teachers in this cluster stressed both cognitive and basic-skill goals, as well as microcomputer use as a goal in and of itself, used a variety of instructional modes to meet these goals (e.g., drill and practice, tutorials, simulations, microworlds, games); they integrated the content of microcomputer-based instruction with the ongoing curriculum, and coordinated microcomputer activities with other instructional activities; changed their uses based on feedback from students; and, not surprisingly, were evaluated as most successful in their use of microcomputer-based instruction during field visits by our staff. Of the four clusters, the orchestration cluster represented the fullest instructional

> use of microcomputers in ways set forth in our definition above. (p. vii)

Other patterns of use which proved considerably less valuable than orchestration were called enrichment, adjunct instruction, and drill and practice.

In looking at the distribution of the four types of use, Shavelson et al. found that classrooms with students above average in ability and a low percentage of minorities tended to be taught by orchestrators, while in the classrooms with a high percentage of minority students low in ability, computers were used in the less effective ways.

The Center for the Study of Schools (CSOS, 1983-84) recently published data on classroom organization and computer use which is the result of a national survey of 1,082 microcomputer using schools. Their survey revealed that almost all elementary schools and nearly half of the secondary schools had only one or two computers per classroom if they had any at all. Therefore, a major issue for a classroom teacher with a computer is organizing computer time effectively. Among other things, CSOS reported on a number of different organizational strategies dealing with access to computers and time spent not on computers.

As we might expect from our review of classroom organization (section 4), the most common classroom organization is whole-class, with seatwork occupying the students not working on the computer. Only in junior high school programming classes does "watching" constitute a major activity for students not on the computer. After analyzing their data, CSOS concluded that the most effective arrangement is to have classrooms organized in centers so that time will not be wasted for students not using the computer.

Detailed Studies of Computers and Classroom Organization

As we indicated in our discussion of the classroom context, a recommendation for organizing classrooms into centers would be consistent with other research aimed at enhancing learning, but much detail needs to be specified to indicate how students are split into groups to attend centers and how materials, activities, and participant roles are structured if the aim is to be achieved. Two studies that combined observation and intervention indicate the range of issues that must be considered in a characterization of the relationship between computer use and classroom organization.

Computers in the Classroom Project

Mehan, Moll, and Riel (1985) studied how the availability of one or very few microcomputers in classrooms has an influence on (a) the arrangement of the classroom and (b) the curriculum. They observed the introduction and use of microcomputers in four elementary school classrooms in the north county area of San Diego during the 1983-84 academic year. One classroom was part of a designated bilingual program; two others had a number of students who spoke Spanish as a first language; and one was a Title I (educationally disadvantaged) classroom.

All four of the teachers were expert teachers, but not all were experts in the use of microcomputers. Two of the teachers had neither used a microcomputer on a regular basis previously, nor had formal training in computer programming or computer use. The other two teachers had extensive experience using microcomputers but had not had them available for full-time classroom use prior to this project. The teacher in the bilingual classroom had a particular difficulty about computer use: The limited range of software available in Spanish reduced her choices of activities, until she and the project researchers adjusted some materials to fit into the Spanish part of her program.

The teachers organized tasks for the microcomputer that were coordinated with activities carried out during other parts of the classroom day. Reading and writing activities that were taught using paper, pencils, and chalkboards were coordinated with activities that were taught using the microcomputer. For example, a poetry writing activity begun with paper and pencil was extended to the computer center where a similar writing activity took place. When introduced with this role in the language arts curriculum, the microcomputer was a new means to meet previously established educational goals.

Mehan et al. concluded that the introduction of a microcomputer for the purposes of instruction did not substantially modify existing spatial and temporal arrangements in the four classrooms. At the start of the year, all teachers used a mix of teacher-led whole-class lessons with teacher-led small-group lessons, and some encouraged peer-group lessons. The same patterns were found at the end. However, the availability of a microcomputer added a new dimension of participation to the classrooms. Each of the teachers in this project decided to have two students work at the computer at one time. The teachers made these decisions for pragmatic and pedagogic reasons. Naturally, this doubles the total access time that a student has to the computer. However, it also introduces a new dimension to learning interactions.

Dyadic peer interaction was the new "structure of participation" (Philips, 1982) that emerged when two students were placed together to work at the computer. Students were given assignments for work sessions at the computer by the teacher, either verbally at a whole-group orienting session or in writing at the computer center itself. Students worked together on the activity carrying out the teacher's assignments without direct adult supervision. When they had difficulty with computer operations, they often called the teacher for help. However, the teachers' responses were to encourage the students to use each other as resources, consult the written instructions around the computer, or go to other students for assistance. Although the teachers did not monitor the students' work at the computer directly, incidental teacher evaluation was almost always present.

As is reported about peer learning activities that do not involve computers, the students assisted each other at the computer in ways that were productive: correcting each other's mistakes, cooperating in the completion of assigned tasks, and discussing the assignments in ways that clarified the task, even when it appeared that neither partner understood the task at the outset. Some specialization within tasks was also observed, e.g., one student handled typing and spelling while the other concentrated on more global issues such as the construction of the essay and coherence among sentences. (Although the permanence or transience of such specialization within pairs of children was not discussed for the general activities, Mehan et al. did comment on role alternation in an innovative activity that was introduced into these classrooms—the Computer Chronicles, described below. During that activity, the specialization was characterized by role alternation rather than having one child become the permanent speller and the other the permanent coherence monitor.)

Improvement in the students' reading and writing occurred, in part, because the screen editing and printing capabilities of microcomputer systems improved the production of students' texts by subordinating the mechanical details of writing (such as producing neat script, spelling accurately, and correcting errors) to the higher order goals of clear writing, fluency and the flow of ideas (cf. Daiute, 1982). Equally important, however, was the social organization around the microcomputer that changed both what was taught and the way in which it was taught in these project classrooms.

Widening the social sphere involved in the classrooms, Mehan et al. intervened in the curriculum by establishing a student newswire service known as the Computer Chronicles in the project classrooms (cf. LCHC, 1982; Levin, Riel, Boruta, & Rowe, 1984; Riel, 1983a). Students wrote and edited articles and exchanged text-filled computer disks with children in Alaska, Hawaii, and Mexico so that children in each location could produce local editions of the Computer Chronicles newspaper, choosing among stories available from all the participants in the newswire. Whenever possible, students' attention was focused on the parallels between their work and the work of newspaper editors and reporters who use international newswire services.

This intervention allowed the teachers to establish learning environments organized for communicative purposes, not merely for teacher evaluation. The presence of an audience for writing, in the form of classmates, parents, and peers in Hawaii, Mexico, and Alaska, was a crucial ingredient in making the Computer Chronicles a functional system for reading and writing. This writing for a purpose, not "just writing" or even writing on the computer, subordinated students' concern for the mechanics of writing to the goal of communicating clearly.

Mehan et al. (1985) concluded, that, in the cases they studied, microcomputers were assimilated into existing classroom arrangements but were associated with changes in teacher-student relationships and curricula. Cooperative peer interaction emerged, and teachers were able to achieve educational goals that could not have been achieved as readily had a microcomputer not been available for their use.

However, the researchers' remarks at the end of the first year of work offer sobering thoughts for computer enthusiasts:

> The computer easily becomes an intruder whose potential benefits are outweighed by the inconveniences they create (some of which we have already described): The strategy of choice then becomes, not by design but by necessity, to accommodate the machine to the prevailing constraints. This decision, although pragmatic in the short-run, is absolutely fatal, especially for language minority students, because it assumes, uncritically, that the status quo is the appropriate context for computer use. Inevitably, existing curricular practices become the "model" for computer use. Why should we expect that the same practices that have produced widespread academic failure will create propitious environments for computer use? (p. 226)

Writing in the Classroom

Cazden, Michaels, and Watson-Gegeo (1984) reported complementary findings in their study of the introduction of microcomputers into two sixth-grade classrooms for writing activities. Both classrooms were organized with mostly whole-class instruction but with ability grouping in reading. However, the pacing of the day and the role of the teacher differed in the two rooms. In one room, students were expected to be working constantly, completing weekly contract work at their desks when not engaged in a formal lesson. The other class was leisurely paced with many blocks of free time; students were allowed to work at their own pace on different activities. "Quill" writing software was used in both classrooms on a single microcomputer to enter finished written pieces or to type a letter to a classmate via the electronic mail program. Editing was neither required nor directly taught, but some children in each classroom picked up knowledge about text editing commands. The classrooms differed in the way student interactions around the computers were organized and how computer commands were taught; as a consequence, knowledge about computers and text editing skills was diffused among the students in different ways (cf. Michaels, 1985).

In one classroom the teacher gained expertise in the use of the computer in the course of the first semester. She became the classroom computer expert to whom the children came with problems. She also posted a chart of basic editing commands on the wall near the computer. The computer was an attraction at the back of the classroom, and children were assigned to work in pairs, with one child typing in text from a draft and a "helper" reading the draft aloud. These pairings were determined by the order students finished their rough draft and had it edited by the teacher. As a consequence pairing crossed sex and ability lines.

In the second classroom, the teacher did not gain expertise on the computer. One boy learned editing skills and became the editing expert. Students were allowed to pair up as they wished. Most of the pairings were same-sex. Tests in each classroom at the end of the year showed that, in the first classroom, knowledge of editing commands was widely diffused among the students, equally among boys and girls. In the second classroom, only friends of the one computer expert in the class demonstrated knowledge of editing commands, and they were boys.

Summary

Both studies reviewed above demonstrate the extent to which participant structures shape the effectiveness of the computer in the classroom. In the study by Mehan et al., it was the emergence of dyadic peer interactions and the inclusion of "exotic" audience participants that were highlighted as important to the success of computer use for the teacher's goals and for the children's academic achievement. In the Cazden et al. study, the participation structure in one classroom encouraged cross-sex and cross-ability dyads and resulted in widely diffused knowledge of the computer as a word processing tool; in the other classroom, the knowledge spread only to sex pred[illegible]ble bounds, following on same-sex dyads during instructional time. In both cases, there is reason to worry that a laissez-faire attitude toward social organization during computer introduction may contribute to the recapitulation of the status quo, including less effective education for women and minorities.

How Many Computers Per Classroom?

The number of computers was held constant at one per classroom in the two studies discussed above. This reflects the national average of one or two computers in classes with microcomputers (CSOS, 1983-84). In most of the CSOS classrooms, only one child actively worked on a computer at a time, with some assistance from other children. The number of students at a computer at one time varied among the schools, however, and CSOS reported:

> Our data show that in schools where use is concentrated among above-average students, the primary computer-using teacher reports a more "individual-use" pattern than in schools where "average" students get a proportionate share of student computer time. Use by "average" students is instead associated with students using computers in pairs.

Teachers perceived that students' learning and enthusiasm were high working individually in programming classes but with drill-and-practice software students worked better in pairs or small groups.

At one extreme, Papert (1984) recommends one computer per child for classroom use and one to take home. Considering the costs of such an undertaking, it is a good thing that existing research suggests that one computer per child is probably not an optimum number, at least at the elementary school level where the issue has been most extensively studied (Levin & Souviney, 1983; LCHC, 1982; Trowbridge & Durnin, 1984).

There is growing evidence that two students working on a machine reduce low-level errors and create support for higher level activities when compared with students working individually (Levin & Souviney, 1983; LCHC, 1982).

Two students are likely to have different skills. By working together and dividing the labor of the task, they can bring their separate strengths together to get the task accomplished. In the study by Mehan et al. (1985), the students began by taking short turns at the computer, but gradually, the size of the turn units changed: Students started out dividing the labor at the level of keystrokes; as they developed some proficiency and gained control over the coordinated parts, they began to write one story per turn, providing for a kind of role-alternation between writer and assistant.

Trowbridge and Durnan's work complements this conclusion by its comparison of group sizes ranging from one to five children per machine. As in the Levin and Souviney and LCHC work, low order entry-level errors were reduced when two children worked together. When group size was increased, the organization of work broke down, and students were observed to engage in less effective learning at the computer.

These findings are very limited, considering the importance of the issue. At present no systematic research exists on the interaction of student characteristics, number of machines per classroom, and curricular content.

Impact on Women and Minorities

Patterns of diffusion of microcomputers into the schools indicate that this new technology is creating a virtual epidemic of inequality. (See reports by Quality Education Data, CSOS, 1983-84.)

Wealthier schools get more computers and they do more interesting things with them. Within each school, access and patterns of usage favor males over females and higher achieving children over lower achievers. This situation has begun to evoke a well-articulated concern, especially in the case of sex differentials in access and use. Because the issues relating to sex bias and ethnic/cultural variations are somewhat different, we will discuss them separately.

Girls and boys. A growing number of studies have indicated a wide gap between the experiences girls and boys have with microcomputers. Boys overwhelmingly spend more time on microcomputers, arcade or educational, than do girls. More boys than girls take programming classes and become classroom computer experts. Parents are more likely to provide the means for computer literacy class for their sons than for their daughters. Boys are more likely to participate in after-school clubs and activities where computers are available. And, not coincidentally, more men than women go on to obtain the high paying computer-related jobs in our society.

Obviously, there are many factors contributing to this inequality. The perception of computers as belonging to the traditionally male domains of mathematics, science, and "machinery" is a major social factor. The competitive nature of many computer activities, the war themes of the arcade games, and the overall male bias in software are other factors. This inequity is not universal, however. More women than men use computers in vocational business classes, preparing for jobs in word processing and data entry. Thus, although computers are not restricted to the male domain, the inequality is controlled by the activities that computers are a part of and that continue to be divided along traditional lines.

In the discussion of classroom studies of computer use, we cited Michaels' finding of differential diffusion of text editing commands as the result of different pairing strategies the teacher used. The poor showing of the girls appears only under certain circumstances. In the research conducted by LCHC (Griffin & Cole, in press), there is further evidence that, given the right support, girls can become computer experts as readily as boys. Girls tend to be more social around the computer, more cooperative and less competitive when working together. Many of them seemed to enjoy the role of teacher, using what they knew to help out younger children. If it is true that these are reliable social differences between boys and girls in our culture, then working in pairs or small groups is a possible way to facilitate learning for girls with microcomputers. There is a need for more research on these issues.

If computers are to be a part of the improvement of the status of women in our society, the potential they have for reorganizing the context of learning must be exploited. The computer must be used to do something different. Throughout this report, we discuss a number of ways in which the context of education can be reorganized to facilitate learning. These include changing the social organization of the classroom; changing the goal of educational activity; changing the relationship between the classroom, the school, and the community; and changing the lesson activity itself to give each student a supportive environment for learning. The introduction and use of computers in classrooms must be seen as part of such systems, not as independent innovations, if they are not to introduce new problems; investigations of mathematics education programs for women which were instituted in the last few decades provide a good lead.

A large number of intervention programs designed to increase the participation of women and girls in mathematics, science, and engineering have been surveyed by AAAS (1984). Elizabeth Stage and her colleagues Kreinberg, Eccles, and Becker (in press) have analyzed the common features of successful intervention programs. These are highly motivated teachers, strong academic emphases, multiple strategies, and systems approaches. Although it takes place in an educational setting outside school, and thus properly belongs in section 7, the EQUALS program illustrates these principles quite well.

The Lawrence Hall of Science at the University of California, Berkeley, developed the EQUALS program to give girls experience with mathematics outside their regular classrooms. Their program includes a special class called "Math for Girls," a "Family Math" program, and an inservice workshop for teachers designed to increase awareness of the obstacles faced by girls and to give specific suggestions for implementing programs to facilitate mathematics achievement by girls in the classroom. The mathematics classes are for girls only because of a belief that girls do better in an all-female environment. Families are included because support from parents and community is required for any lasting change. One of the most effective aspects of the program has been the impact on teachers' attitudes toward mathematics. Many teachers are women who themselves were not confident in their mathematics ability.

EQUALS succeeds in involving girls in mathematics, science, and engineering because it changes the context of their education. The family is involved; role models, women who are making it in "male" occupations, demonstrate the real applicability of mathematics and related lessons; mathematics is taught not as a stand-alone system, but as a means to accomplish other, more interesting objectives. Other intervention programs bring business and research institutions into the process, further emphasizing application. Recently, computers have been added to EQUALS' mix of activities.

In addition to following the lead of EQUALS and other successful programs described by the AAAS study to develop programs that will give girls a good chance of developing expertise with computers, the introduction of computers can be made in such a way that girls can find them more inviting. A widely held belief about computers is that they require prior training in logic, a good mathematics background, or a native ability to "think abstractly" on the part of the user. But computers also involve language and interactivity, two traditionally "female" domains of expertise. If computers are used to augment curricula in language arts as well as mathematics or science, there might be a carry-over effect from the areas in which girls function more strongly or confidently. As an entry point to technological literacy, language arts is as viable as arithmetic or mechanics. The logic internal to "direction giving" as a genre, for example, affords natural comparisons to computer programming or experimental procedures in science. The narrative structure of storytelling can be transferred profitably to science, where it becomes a powerful observational tool (see section 7, School-Oriented Mixed Media, regarding The Voyage of the Mimi).

Educators in general have failed to exploit the analogies between domains and the skills that are applicable across domains. The effect of this failure is that children with different backgrounds of experience and expertise are not given the entry level support they need to gain access to new domains. Computers with software designed specifically to maximize the similarities across domains could assist educators to take advantage of expertise which they (and little girls) often claim to be in the province of girls. The potential of computer microworlds to allow learners who are strong in language arts access to areas like mathematics and science is underrealized; further, it is one of a very few positive aspects in the current view of the future for girls in schools with increasing numbers of computers.

Minorities. The special issues relating to minorities and computers in education share much in common with the problems faced by women because of their economic status, cultural norms, and social practices. But these groups labor under a somewhat different mix of impediments. The distinctive impediment we will focus on here arises from widespread acceptance in educational practice of the Level 1/Level 2 approach to curriculum sequencing discussed at the beginning of this section.

This basic set of assumptions is reflected by the fact that even when minority schools have computers, the quality of usage is judged low (CSOS, 1983-84; Shavelson et al., 1984). Low quality usage is variably defined. In the Shavelson et al. report it refers to nonorchestration methods of organizing computer activities, which happens most often in minority schools. For the bilingual classroom described in the Mehan et al. report, low quality usage included a teacher who is a novice to the machine and for whom appropriate software is in very short supply. In the CSOS report, low quality referred to drill-and-practice programs in place of enrichment activities.

The drill-and-practice emphasis in minority schools implicitly adopts the Level 1/Level 2 theory of mind and instruction. It also fits with a curricular strategy that places heavy emphasis on learning to decode words before learning how to comprehend or learning basic math facts before taking on word problems or long division. The widespread use of this educational strategy has, where proper management techniques are used, brought children up to grade level on the basics but failed to boost them into higher order activity. Widely discussed as the third- and fourth-grade watershed, the heavy focus on Level 1 skills seems to help children do only what they were trained to do in a rote way; there is no transfer of the knowledge up to a higher level of learning. A number of minority group children get stuck at Level 1: They are not exposed to practice with activities at higher levels of the curriculum when they do not demonstrate mastery of the basics. This failing is then attributed to the children's innate lack of ability for the higher skills, which they were neither tested on nor taught.

The circularity and incoherence of such pedagogical moves are apparent. Furthermore, there are excellent reasons to believe that the Level 1/Level 2 theory is wrong even for the experimental data that justified the distinction in the first place (Mandler, 1977). Yet it recapitulates itself with great regularity with every move back to the basics. Unless this recapitulatory pressure is recognized and dealt with self-consciously, it can be expected to make the academically rich richer without increasing significantly the academic capital of the poor.

This is a clear case in which computers can make a difference because they can be used to create environments where the Level 1/Level 2 distinction is eliminated. A number of innovative software systems are being made that implement simulations, create dynamic microworlds, and regularly defeat the distinction between Level 1 and Level 2 activities (CUSG, 1983; diSessa, 1984; LCHC, 1983; Riel, 1983a, 1983b; Vaughn & Casey, 1983). Learning of basic knowledge can be made to occur within constraints set by higher order goals; rote learning can co-occur with transformations on the input; i.e., the sort of combined system than Mandler's experimental work suggests would be effective and efficient for learning. If the introduction of computers into a classroom is accompanied by the use of social and software systems that blur the Level 1/Level 2 distinction, then there would be a valuable contribution made by new technologies to a thorny problem in pedagogical practice.

Bilingual Education and Computers

Whatever the potential of computers for the education of linguistic minorities, it has not as yet been realized on any large scale. In the years since the Mehan et al. study that included a bilingual classroom, the situation has not improved a great deal with respect to the availability of varied software for students whose first language is not English.

One current project warrants particular notice for its success in blending computers into a bilingual educational setting to enhance learning English, the language of the dominant culture. The problem of limited software was circumvented by a kind of "social engineering" that makes bilingualism a resource instead of a difficulty.

The project grew out of the work of Moll and Diaz on a "bilingual mode" for the classroom organization of English reading instruction that was discussed in section 4. In that earlier work, the key to improving skills in second-language literacy activities was to subordinate the ongoing activity to the goal of comprehension, allowing the first language to mediate where and when needed. This same principle applied in settings involving computers appears very promising as a means of increasing both basic language skills and computer literacy skills.

In their computer work, Diaz and Moll have organized activity settings designed to make children "computer experts" in the eyes of their teachers and members of their community. This expertise is evaluated not only in tests, but also in the requirement that expertise be demonstrated by teaching others. Their curriculum requires children to learn how to assemble the peripherals for Apple computers; learn about basic concepts of information flow and storage in the computer; and learn to do text processing, telecommunications, and programming. In addition, children act as software evaluators. All but a small fraction of the software is in English, although the children are Spanish-dominant.

Adopting the successful procedures from their reading work, Diaz and Moll do not insist on English language use at any point in the proceedings. But the underlying assumption of all the activity is that English will be mastered as a part of becoming expert in the use of computers. Consequently, there is a good deal of language switching in the course of reading articles about computers, using the software, and writing (either in the form of software evaluations or using the telecommunications system).

As reported by Anderson, Diaz, and Moll (1984) and Duranti, Diaz, and Anderson (1984), this system appears to have unusual power to change the academic performance of children, not only with respect to the concepts and activities that are the core of the curriculum, but also in their use of English overall. An additional bonus is that the children's status changes in the eyes of their teachers, who are impressed with their ability to learn about computers. Among the biggest effects of the program are improved behavior in school and increased attendance at school, both of which contribute indirectly to improved academic performance.

An important aspect of this work is the emphasis it places on context arrangement, rather than software, as the key to success in bilingual uses of computers. A clear requirement is the availability of adults who know both languages involved, but these people need not be the primary experts in computer use. Rather, the social setting must contain the right mix of resources deployed appropriately to obtain the right educational systems properties.

Non-Real-Time Teaching with Computers

A small but growing body of evidence indicates that the potential of non-real time in course-related computer messaging can amplify student participation in productive learning exchanges. Electronic mail use among researchers has been a growing phenomenon (cf. Newell & Sproull, 1982) where the informality of a face-to-face conversation is merged with the non-real-time advantages of letters. The potential of electronic mail for reorganizing teaching and learning is beginning to be recognized. Both the application of this technology to instructional settings and research on it are in their infancy. We describe here a few examples of the way this use of the technology can address educational issues especially relevant to students who have less success under more ordinary instructional conditions.

Black, Levin, Mehan, and Quinn (1983) reported that college students learning to analyze classroom interactions gave longer and more thoughtful answers in response to teacher questions via a message system than when responding in class. In addition, students exchanged information with each other in spontaneous comments on each other's comments that were prototypes of good thinking very rarely encountered in teacher-led classroom discussions. An important finding in this study was that the weaker students were particularly helped by the message system interactions. Scollon (1983) reported similar findings.

The Department of Communication at UCSD (Karpowicz, 1984) experimented with sending messages in a large lecture class. A section of 30 students obtained two extra units for a writing "adjunct" course based on the topic of the lectures. The students self-selected to participate on the basis of perceived needs to improve their composition skills.

These students not only completed as many as four drafts per paper but also sent messages among themselves about the topics of the course in a very productive way. As a result of the experience, a number of the students requested permission to continue their messaging work because of its powerful effect on their writing and class work.

Harnessing electronic mail systems for instruction is relatively rare at present. We have provided examples in which the electronic communication is a part of a system including face-to-face meetings; there are courses available that are fully implemented on computer networks, carried by commercial utilities and accorded credit by participating universities. More basic research is needed on the systems properties of off-line communication that may be critical to the success of this medium for instruction (Hiltz & Turoff, 1978; Johansen, Vallee, & Spangler, 1979). There are many elements to be considered. When communication is via computer, offline, a few minutes to a few hours can intervene between "turns" in the dialogue between a speaker and a listener. There is an "audience effect." By sending messages to a selected number of other class members (or even outside contributors), a message is made more or less public. Both of these features—flexibility in when to answer and flexibility in who will "hear" the answer—give more room to maneuver to those students who feel reluctant (for whatever reason) to participate actively in classroom discussion. (See Scollon, 1983, for a provocative exposition of the issues involved.)

To date there has been little systematic information about how this added medium of telecommunications and computers interacts with various possibilities from other media (lectures, television, small group conferences, etc; see below for a discussion of mixed systems). Nor is it known how properties of off-line instruction interact with the subject matter or the students' levels. All of these questions invite research, both theoretical and applied. What is known is the power of such systems, when properly devised, to provide weaker students with an especially useful boost, using new technologies as a medium rather than a crutch.

6 • Activity Systems at the Level of the School

As Harnischfeger and Wiley pointed out in the passage cited at the beginning of section 4, there are constraints on effective learning time that are controlled by forces operating at the level of the school. School level and classroom level factors are not totally orthogonal to each other. They interact in patterned ways that bespeak of a distinctive culture of the individual school that can contribute to the performance of students as a group. School activity systems also concentrate on the careers of individual students as they move through the educational system and are placed in particular programs or major in particular fields. These systems properties are beginning to be understood, although a good deal remains to be done before such understanding can elevate the creation of exceptionally effective schools from an art to a science to systematically optimize students' school careers.

Effective Schools

This section draws on the massive study undertaken by Rutter and associates in England (Rutter, Maughan, Mortimore, Ouston, & Smith, 1979), which fits with a good deal of research in the U.S. on schools-as-systems and the systems properties that seem to lead to better-than-expected academic outcomes. Purkey and Smith (1983) reviewed a large number of studies on effective schools, ranging from earlier studies through case studies to program evaluations; they pointed out the difficulties (which our committee has come to expect) that occur in evaluating evidence, analysis, and argumentation when multidisciplinary studies of diverse types are aggregated. Yet Purkey and Smith pointed to commonalities in the literature, suggesting that concentration on one study, like Rutter's, provides a good window into the relevant research; they found Rutter's longitudinal study of secondary schools, using a variety of student outcome measures in the analysis, a unique and particularly good case study.

Rutter et al. studied the organization of instruction in 12 urban English schools. Only two of these secondary schools could be called fully effective (in terms of test scores, behavior, attendance, and delinquency). Rutter arrived at 10 generalizations, from which more detailed conclusions are drawn:

1— There is wide variation among schools in the academic performance of their students.

2— Differences in the proportion of behaviorally difficult or low achieving children they admitted did *not* wholly account for school differences in output achievement.

3— Differences in outcome were stable over a 4-5 year period.

4— Schools that scored well in one category of outcome tended to score well across the board.

5— School differences were *not* the result of physical factors such as size or wealth of the schools, age of facilities, or administrative organization.

6— Differences between schools depended upon such characteristics of social institutions as academic emphasis, teacher actions during lessons, incentives and rewards, level of pupil responsibility for physical well-being of school and their performance—all significantly contributing to outcomes. All of these factors are open to manipulation by the staff, not externally fixed.

7— Outcomes are also influenced by factors outside teacher control. Balance in academic preparation among students is most important, as is the presence of a "substantial nucleus" of children with at least average entering skills.

8— Balance has the biggest effect on delinquency, not in-class behavior acceptability.

9— The big effect of schools comes from a combined index of the in-school process factors (see below) not individual factors. This leads to the conclusion that there is a "culture of the school" which works.

10— Longitudinal data indicate that the schooling impact is a cause, not a consequence, of entering or context factors.

Although the school effect is a whole system phenomenon, it is possible to see its mediation by group management in the classroom. These classroom level features are a part of the culture of the school. Rutter and his colleagues noted these management generalizations about successful classrooms:

1— Teachers prepare lessons in advance.
2— Students are kept actively engaged in productive activities rather than waiting around for something to happen.
3— Minimum time is spent repairing difficulties with individual children.
4— Amount of formal punishment makes little difference, but *frequent* disciplinary moves are linked to *more* disruptive behavior in classrooms.
5— Teachers who are successful in classroom management tended to spot disruptive behavior early and to deal with it appropriately and firmly with a minimum of lesson interference.
6— High levels of discipline are *not* strongly related to proportion of problem children at intake.

Rutter et al. identified four value features of the school culture that are central for producing positive effects in target schools:

1— Expectations and standards: Children had better academic success in schools where homework was regularly assigned and marked and where teachers expressed expectations that a high proportion of the children would do well on national exams. Schools that expected children to care for their own resources had better behavior.
2— Models provided by teachers: Teachers who care for their classroom environment and manifest readiness to see students at any time provide *positive* models. Teachers who end lessons early and who engage in

unofficial physical sanctions are negative models, setting up negative classroom interaction patterns and reduced performance.

3— Feedback: High levels of praise in class, coupled with awards and prizes at assemblies, have positive motivating effects. (There is explicit acknowledgement of the danger of negative effects of external motivation, but the argument is made that prizes work effectively as a supplement to inclass praise.)

4— Consistency: Crucial to the effectiveness of the school is the consistency with which the values/norms/expectations are embodied across contexts within the school. The school must function as a coherent whole with active approval of all segments of the population for the individual strands to come together to produce positive outcomes.

Cohen's research in the United States points to an additional school characteristic that matters for minority students. In the section on student activity groups, we referred to Cohen's research on ways to shift the interaction patterns of low status students by means of what she called Expectation Training. Related research by Robbins (1977) showed that the conditions in which such training is successful includes the status relationships among school *adults*: First are relationships within the classroom:

> Experimental results have shown that Expectation Training will not produce the desired effects in settings where the adults mirror the status order of the outside society, i.e., the Anglo teacher is the "boss" and the Hispanic aide clearly functions as subordinate. Unless the aide and the teacher model equal status behavior for the children, the low status child is likely to think that it is illegitimate in a desegregated setting to speak up and tell high status children what to do. (Robbins, 1977)

Relationships among school personnel outside the classroom —school principal, secretary, guidance counselor—matter as well.

The Selection of School Contexts: Placement Decisions

Chipman and Thomas (1984) provided an extensive review of factors influencing the participation of women and minorities in mathematical, scientific, and technical fields. With respect to sex differences, they reported that "differences in interests, educational aspirations and occupational aspiration that are formulated by the time a student begins high school" are the major factors associated with the lower participation of women. For both women and minorities, achievement levels during the elementary school years appear to be the most important factor in promoting increased participation in later mathematics and science activities. This fact motivated Chipman and Thomas's first action recommendation, reform efforts should "be focused on efforts to develop and maintain high levels of achievement from the earliest school years."

The Chipman and Thomas study cited research implicating teacher encouragement as a possibly important factor in promoting participation by underrepresented groups, but it did not go in any depth into the way that institutional factors might impede the goal of broader representation. A good deal of evidence indicates that attention must be given to such factors in determining how a student gets into an effective or ineffective school, track, classroom, or major course of studies. Within our framework, this inquiry becomes an examination of context-selection mechanisms.

In her cross-cultural research on children's socialization into adulthood, Beatrice Whiting (1980) concluded that adult impact on children is at least as great as the influences of within-family socialization patterns, owing to the way that adults select the contexts into which children will be placed. Analogous to this, we look to the context selection settings that occur in the educational careers of students with two examples, young adults in junior colleges and youngsters in the early part of their school socialization.

Several ethnographic studies of "gatekeeping" encounters in schools (such as interactions that involve academic counseling and decisions about special placement) have demonstrated that those relatively poor in "cultural capital" (Bourdieu & Passeron, 1977; Collins, 1979) have a relatively weak voice in such settings. The specifics by which the weak are rendered relatively voiceless differ from one setting to another, making blanket generalizations difficult. But the fact remains that, at educational context selection points, minorities and women are at risk of being selected for contexts that bode ill for academic success.

Erickson and Shultz (1982) conducted interactional analyses of videotapes from counseling sessions in junior colleges. Following consultation with a counselor, some students enroll in classes for the next academic term that are coherent with consistent goal orientation toward higher education or career placement; other students, in contrast, schedule classes that have little apparent relation to either their past history or their aspirations for the future. Microethnographic analyses of the counseling sessions and extensive interviews with the participants led Erickson and Schultz to posit that the crucial variable related to obtaining and making use of effective counseling is "particularistic comembership" between student and counselor. Students with identical academic records are counseled differently; students with very diverse academic records are engaged in effective counseling interchanges as long as the student and counselor have (and reveal in the course of the session) aspects of their past history and current activity that indicate that they have "selected into" particular contexts in common —that they are comembers. Thus, as is the case with the magnification of the effect of early tracking into low groups, the consequences of early context selection mechanisms enter into later events, like junior college counseling sessions, whose main point is to select the contexts for preparing for the world of work or higher education.

At younger ages, educational placement is often determined when the student is not present, yet comembership again comes into play. For placing students in special programs (for gifted, bilingual, or educationally disabled students), many school districts convene meetings to which parents and classroom teachers are invited as well as specialists who have less contact with the child whose future is to be affected by the meeting. Mehan, Meihls, Hertweck, and Crowdes (1981) found that the contribution to the decision making by the parent and classroom teacher is minimal and/or minimized; more is contributed by the psychologists, special education teachers, and administrators who are comembers in that they share information about the technology of assessment and the budgetary constraints of the school district. Standardized tests, interpreted by an educational psychologist, exert a large influence; even more controlling is the availability of money in differently defined categories of posttreatment contexts (Mehan et al., 1981).

In considering the embedded context framework, it is important to keep in mind that the conceptually distinct levels are really interacting to constitute each other and that causal events at different levels are not transparently related to each other in one-to-one correspondences. The need to keep this axiom of the social sciences constantly before us has led to a renewed appreciation for the importance of the institutionalized modes of mediation between contexts and their personal consequences for students. Thus the transitions between classes in a school—and from elementary to high school and high school to the world of work or higher education—assume special importance. Effective schools research needs to be integrated with research on school careers; practical activity to increase the effectiveness of schools needs to involve practical activity to increase the effectiveness and fairness of counseling and decision-making processes.

7 • The School in • the Community

The knowledge that activities within a classroom and at the level of the school can make a significant difference in effective learning time and student achievement is important because it allows us to reject the notion that it is necessary to change the whole system or nothing at all. However, virtually all of the research on effective classrooms and effective schools confirms the limits of within-system change at the classroom and school levels. Transcending these limits requires either global changes in society as an antecedent condition, a process in the domain of politics that assumes no relevant sources of variation within the system, or taking advantage of intersystem links to form new, mixed systems that have the requisite educational properties. It is to this latter possibility, systems that mix classrooms and schools with the larger contexts of their communities, that we now turn our attention.

The widest level of context that we have depicted in Figure 1 is that of the school in its context, the community. We will consider three different classes of interconnection at this level: between the school and the home, between the school and various nonschool organizations such as museums and zoos, and among all of these contexts using mass communications media. Each of these linkages offers a different mix of opportunities for enhancing the goals of improved academic achievement and of technological literacy.

The Interface Between Home and School

This topic is very difficult to address in a meaningful way. Historically accumulated understandings of the respective roles of home and school in education bring largely unanalyzed assumptions into the discussion, obscuring very difficult scientific issues.

Some of the difficulties in research in this area are illustrated by the following examples. The attribute used most commonly in research on home and learning is socioeconomic status (SES). SES, usually measured by parental education, income, and occupation, correlates with outcomes in mathematics and science (Bidwell & Kasarda, 1975; Hanushek, 1972), but this correlation may be misleading. Student ability is a much more significant factor in predicting achievement than home environment, particularly for nonwhite students (Rakow, 1984; Rock, Ekstrom, Goertz, & Pollack, 1985). Parental behavior does appear to make a difference for both minority and majority students and for males and females (Gemmill, Bustoz, & Montiel, 1982). The support and encouragement from parents is crucial to participation of females in mathematics, but parents give daughters less encouragement than they do sons (Fox, 1977). Similarly, educational resources in the home facilitate learning (e.g., Rakow, 1984; Walberg, Haertel, Pascarella, Junker, & Boulanger, 1981), but American female students are less likely to participate in science-related activities at home than are males (Hueftle, Rakow, & Welch, 1983).

Over time, what has developed is a strongly asymmetrical relationship between the home and the school with respect to the power to define what constitutes relevant instruction. This asymmetry appears to have co-evolved with schooling in the service of modern economic systems based on high levels of technology and is by no means restricted to the United States.

In all industrially advanced countries the educational system succeeds differentially with portions of the population that come to be considered "mainstream" and serve as the criterion against which deviant populations are characterized. "Mainstream" is a slippery and protean concept, but in the United States it means largely male and white middle class. By this characterization, the populations of special concern to our committee are decidedly nonmainstream.

The asymmetry in power between the two groups coincides with claims about greater and lesser virtue, which is associated with intellectual achievements. Too often discussions of home-school relations occur against the implicit acceptance of an outdated view of cognition that still haunts twentieth-century social sciences, in which an idealized scientific mind is pitted against an unexamined "primitive mentality" that was early expanded to include the lower classes, women, and minorities of many varieties. (For summary critiques, see Lave, 1984; LCHC, 1983.)

These beliefs are built into the vast majority of studies designed to examine the antecedents of school success in the socialization practices of the homes. The home practices among successful students are used as the criterion against which the value of home practices among unsuccessful students is judged. On the assumption of a simple causal relationship, efforts are then made to improve school performance by intervening somehow in the home setting to overcome practices and values considered deficient.

There are several negative consequences, for both science and educational policy, that arise from this set of presuppositions.

1— When one defines the problem as the need to investigate the deficiencies in achievement for minorities and women, one implicitly locates the problem in the population, bypassing the role of the school in creating school failure. This undermines attempts to do research on the properties of the interacting systems of home, school, and community and to undertake practical action that attempts to change relations among these systems and/or parameters within several of the systems in one project.

2— There is a great tendency to define such "problematic" populations in homogeneous terms, which more often than not get translated into a unidimensional cognitive deficit (defined variously as an absence of higher order intellectual skills or inappropriate cultural/cognitive styles). This alienates research of educational import from other current work in learning and development which emphasizes the content and context specificity of intellectual functioning and assessment. It makes more difficult the implementation of practical programs that emphasize the value of high expectancy for success on the part of teachers and students.

3— A concomitant tendency is to think of the subject populations as passive vehicles that simply absorb the instructional efforts of the school more slowly. This flies in the face of recent research that

> emphasizes the active role of the learner in constructing knowledge and promotes a research strategy that denies the validity of basic research on nonmainstream groups, relegating studies of such populations to comparative research. It promotes educational research that is limited to investigations of various ways to modify findings from other populations, rather than to "start from the beginning" to build effective training and assessment. The consequence for practice of this tendency is either to embrace tracking or to slow down the whole student population, sacrificing excellence for all.

The result of this interlocking way of looking at the issue is an asymmetry in ameliorative efforts, which often places the burden for change on the home. The influence between home and school is not unidirectional; successful programs are successful in large measure because they recognize (and exploit) the permeability of home and school contexts.

McDermott, Goldman, and Varenne (1984) surveyed research on the most obvious practice by which home and school interact around academic activities, homework. This topic takes on additional interest because of the research findings of Stevenson and his colleagues (Stevenson, Lee, & Stigler, 1986) and others (Fetters, Quingo, Suter, & Takar, 1983; Walberg, Harnisch & Tsai, no date) that Japanese students have more homework than American students, making it plausible to believe that the additional "time on task" achieved by this traditional route is an element in the higher achievement of Japanese students in the area of mathematics. Troost (1986) found that Japanese parents also have a high participation rate in schools and that parents and schools both place high demands on students. Consistent with these demands, there are differences in mothers' perceptions about what leads students to succeed: Japanese mothers assigned the highest ranking to the child's effort, while American mothers gave the highest ranking to ability. This attitude no doubt contributes to the greater time spent by Japanese parents discussing school work with their children (Fetters et al., 1983; Stevenson et al., 1986).

Yet these findings are far from definitive. McDermott et al. reported general agreement among parents and school personnel surveyed about their attitude that homework is a "valued and prevalent part" of school programs in the United States. However, the data relating the assignment of homework and parent involvement in seeing that their children complete their homework present an array of complexities. There is clearly no simple relation between the assignment of homework and achievement. In fact, in one large study (Hinckley, 1979), for children in families who reported that homework was brought home more often, that parents spent more time helping their children with homework, and that children spent more time on homework, achievement was *negatively* associated with hours spent on homework!

As McDermott et al. commented, these results force attention to a more finely tuned examination of the family contexts to determine the conditions under which parent involvement in their children's academic work does, and does not, amplify achievement.

We will concentrate our commentary here on three successful projects that combined ethnographic work on home and school contexts with interventions. As one can expect from the nature of ethnographic work and the AAAS report of the specificity of effective programs with specific ethnic groups, there are not generalities at the level of "teachers should do *x*," or "lessons should be like *y*," or "parents should do *z*." The generality is that generalities are often wrong. With this caveat in mind, two similarities among the projects to be discussed can be abstracted: (1) the active involvement of the basic researcher in the school innovation and (2) the involvement of the teacher with very specific information about the local community.

One successful line of work was pursued by Shirley Brice Heath who studied home/school relations in a southern mill town (Heath, 1982a, 1982b, 1983). Against a background of commonly held and often stated assumptions that school failure associated with ethnicity and class could be related strongly to a lack of literacy practices in the homes of the failing population, Heath investigated the issue for more than a decade, concluding that such assumptions could not be substantiated and that changes in the school could ameliorate the situation. Heath's work documents rather dramatic differences in the home and school behaviors of children from different ethnic and social class groups. There is a distinctive style of discourse that characterizes the interactions of successful students in the school; Heath demonstrated the match between this style and the home socialization practices of teachers. She described two other styles also, one associated with Anglo lower-class children, another with black lower-class children, each of which she traced back into their homes.

The first message of this research is that all groups engage in extensive literacy-related practices with their children at home, but that these practices map differentially onto the expectations of the school. Without special exposure of teachers to the patterns of prior knowledge of their students, teachers treat the incoming behaviors of the lower-class black and white students as linguistically and cognitively deficient. Teachers have difficulty building on these children's behaviors for educational purposes, and a spiraling set of problems results, leading to school failure.

However, when teachers are trained to understand the styles of incoming children so that they can build on them, performance among the previous problem populations is significantly improved. To accomplish this positive outcome, a different relationship between home and school must be established. Here is how Heath described the necessary changes:

> Traditionally, education research has emphasized the need to train parents of children who are not successful in school achievement to conform to school practices. Knowledge had proceeded along a one-way path from school to "culturally different" communities. In this research the movement of ideas along that path was made two-way, so that a we-they dichotomy did not develop. (p. 125)

Heath's research is not an isolated case. Anderson and his colleagues (Anderson & Stokes, 1982; Anderson & Thomas, 1984; Ricard, 1985) have replicated Heath's findings of a rich variety of literacy practices going on in the homes of lower-class families (black, Anglo, and Hispanic) living in a different part of the country from the one Heath investigated. As in Heath's case, a marked disjunction appeared when the children arrived at school.

A study by Trueba, Moll, Diaz, and Diaz (1984) substantiated the success of strategies that deliberately create a two-way interaction between teachers and their students' communities at the junior high school level. An ethnographic study of language and literacy activities in the bilingual community and homes of junior high students was the first stage in an educational intervention. The intervention used ethnographic information as a base for developing and improving classroom writing activities.

The key to linking the ethnographic research to classroom activities was the project's view of teachers as research collaborators, going beyond the common practice of viewing teachers as merely research subjects or, at best, as research consumers (cf. Brice Heath, 1982a; Mehan et al., 1985). Members of the research team, including the teachers, developed projects that involved the students and teachers in collecting observational and interview data on the community. All of the teachers involved in the project collected and regularly submitted field notes on their own teaching as well.

Ethnographic observations and documentation modified substantially the judgments of teacher/researchers about students' performance and potential, about the importance of their community life and their world outside school, and about the power of their religious beliefs and their home traditions and values. Writing field notes about their own classroom activities produced two important results: teachers could analyze how they were organizing instruction to achieve specific writing goals, and they could, through the analysis of their notes, evaluate the effectiveness of their teaching. As the project progressed the teachers became aware of changes in the social organization of their lessons.

Dramatic progress in writing was shown by the Hispanic students as the result of the complex and subtle changes in the relationships between teacher and student, teacher and community, and teacher and research. These changes were visible in the formulation of novel instructional tasks, where students played a more active role and where topics of everyday interest in the community became topics of intense field and library research in the writing class.

A third program is aimed at providing bilingual computer education for low-income Mexican-Americans in a barrio in Austin, Texas (Vargas-Adams, 1983). The Center for the Development of Non-Formal Education (CEDEN) is an outgrowth of research on computer education conducted at the Stanford Research Institute in the late 1960s and early 1970s and the experiences of Vargas-Adams of the Cenide Computer Education Program in Spain. That program demonstrated that children from low-income homes could benefit from computer education and that their parents, often illiterate, could take a more active role in their children's learning.

The CEDEN program makes available to the Mexican American parents and their children (ages 3 to 13) a series of teaching and learning resources, including Atari 800 and 400 computers located in a barrio-based "Computer House." CEDEN has been successful in helping the parents and children become better acquainted with, and enthusiastic about, computer learning and in getting parents more actively involved in teaching their children at home as well as at the Center. Most important, according to Vargas-Adams, "the program has served as a cultural bridge between the Mexican-American home and the schools, complementing and supplementing formal education" (p. 57).

Like the Diaz and Moll project mentioned in section 4, this program demonstrates how community-based out-of-school programs can have a positive influence on the education of minority students. The program does not deal directly with problems that bilingualism, biculturalism, and low SES may create in the ordinary educational system; rather, it offers resources, including bilingual support where necessary, to reorient the efforts of parents and students who are working to provide a better future for their children and themselves. Another important aspect, again mirrored in the Diaz and Moll project, is that technology plays a secondary role in the process: the computer is not itself responsible for bringing about important changes in attitudes and skills but merely one of the many means by which change is accomplished. Clearly, the role of the barrio-based Computer House is critical to the success that the program has demonstrated thus far. Mexican-American parents, who often feel alienated from the schools, find it much easier to come to a "house" in their community. They bring their children, young and old, to a place where learning resources are available for them to use. In the course of the time spent in the Center, parents and students are even able to bridge the gap that exists between them and the school. As a consequence, the educational prospects are improved for their children.

The diversity of the communities and strategies involved in these effective programs makes it pointless to track particular bits of information or particular strategies for teaching that cross the barrier from home to school and make the crucial difference in student achievement across the board. However, the effect of contact with the school culture on homes is more likely to show some uniform effects which can be tracked. An important result that appears in the Anderson et al. work is the changes wrought in home socialization practices as a result of contact with the schools. Among families with more than one child, a distinctive pattern of interaction, "doing school work," appears in the ethnographic observations. Younger siblings participate in these events and begin to learn what will be expected of them in the future. This same "feedback effect" has been studied by Laosa (1980) who has found a cross-generational effect of schooling on home practices, mediated by mothers: the more highly educated the mother, the higher the level of academic performance for her children. Piecing together the fragments of evidence from these different methodologies, the interconnection between school and home is seen as a complex two-way interaction, not only contemporaneously but across cohorts and generations. The school-to-home pathway is one that could be more effectively used for the education of young children, and one that is more likely to be effective if the two-way nature of the path is explicitly recognized by educators.

The Potential of Other Nonschool Institutions

The Eighty-fourth Yearbook of The National Society for the Study of Education describes a number of demonstrated successes in amplifying and supplementing school-based education through the educational programs of museums, zoos, planataria, aquaria, and other such institutions. Very successful programs exist at Lawrence Hall of Science, the Boston Science Museum, and the Toronto Museum of Science which operate both as stand-alone operations and in coordination with the schools.

A number of contributors to the NSSE Yearbook predict that nonschool educational settings will take on increasing importance in the coming decades as a consequence of changes in basic modes of production and the intellectual skills needed to sustain them. Fantini (1985), for example, believes that increasing emphasis on new technologies and the new modes of life that accompany them will transform the role of the school from one of coordinating various educational influences, to one of facilitating a lifelong educational process. This new role, he said, will be accompanied by an emphasis on expanding our environments for learning rather than improving the effectiveness and efficiency of *schooling* (p. 61). He echoed Goodlad (1984), Cremin (1976), and others in urging that we think of a community-based system of education rather than one based on the school.

Linkages Among Contexts Using New Technologies

Computer networking and interactive cable video capabilities add new tools for expanding efforts to include greater coordination with schools. These opportunities currently exist in embryonic form and could be expanded through carefully constructed demonstration projects. It is technically feasible to create a national computer communications network with local access; using existing interactive capabilities in phone lines and satellites would put a vast array of scientific expertise at public disposal in an educationally amplifying way. Significant opportunities exist here for cooperation among industry, scientific institutions, and the schools. These opportunities need to be further explored.

In the rush of excitement over computers, the potential of an "old" technology such as television gets relatively short shrift, except as it fits into state-of-the-art systems using laser discs and rapid access computers. A narrow focus on computers as the most promising new technology is almost certainly a mistake; relatively little of the potential of television as a medium has yet been explored, especially the potential for genuinely interactive television. As yet the technical reports on such projects are still poorly digested, but there is some evidence that projects mixing television, computers, telephones, and other media can potentially bring great resources to bear on the problems of education.

Some of these projects involve television broadcasting using public broadcasting facilities aimed primarily at the schools, with the home as a secondary audience (such as Bank Street's Voyage of the Mimi series described below). Other such projects have home viewers as the primary recipients (the ACCESS network under way in Alberta, Canada). Still others are more local in origin, capitalizing on the additional channels available on cable television to make possible the Homework Hotlines that have sprung up in many American cities. There are even some modest attempts to use microwave carriers to hook schools up with each other and some centralized studios managed by school districts that might, at some future time, greatly expand the interactive video capacities for education.

School-Oriented Mixed Media

Only experiments at early stages of development can be reported here. The Voyage of the Mimi project at Bank Street College of Education integrates three media—video, microcomputer, and print—to motivate children and teachers to engage in science activities during regular classroom time. As two young scientists and student assistants go on a 13-episode boat trip to study whales, upper elementary and middle school children see, in a more functional way than they might usually, how science gets done. They observe both scientific problems and nonscientific problems being solved in ways that use mathematics, reasoning and deduction, and the cooperation of a team. They see that scientists are human beings, people they can identify with; that machines can alter our powers to learn about the world; and, very important to the developers of the project, that there are still questions for which we do not have the answers. Even scientists do not: there is relatively little actually known about whales and the ocean. By following such a theme, the child/learner must shift from a consumer of scientific facts to a supposer and question-asker.

Accompanying the television sequence (which also includes 13 documentaries on real projects related to aspects of the drama), are books and computer software. The software attempts to make use of the microcomputer in four distinct ways: teaching LOGO programming with a series of whale search and turtle games; simulating instruments used by the team aboard the Mimi; as a measurement instrument itself; and as a microworld environment where children explore variables in an ecosystem. The computer activities and those suggested in the accompanying books are designed for teams of children to carry out together in cooperative peer groups.

These social and cognitive affordances of the materials are considered important. Certainly group work is often a part of hands-on science programs, but the deliberate division of labor and the emphasis on learning about others through interaction with others is rarely built into the science curriculum. As part of the learning context, the teacher, too, is considered closely in this project. The materials are unusual in that they embody a view of the teacher as one who arranges opportunities for children to ask questions about the world: The content and sequence of activities covered by materials is not fixed, or even particularly delineated. This means that the teacher and children can decide which topics or strands to take up among the fund of ideas presented. The materials allow integration with other subject areas, such as social studies, and with everyday domains; using a narrative drama as a vehicle for science concepts invites the children to relate their own lives to the dilemmas faced by the characters. The teacher is seen not as a conduit for the delivery of the book, television show, or computer programs but as an important element in a system that can be adapted to a wide range of local circumstances.

Mixed Media Aimed at the Home

The Voyage of the Mimi was designed primarily for school use. But it can also be seen in homes, broadcast by PBS. A variety of other experiments depend on local broadcasting, often using cable facilities, to provide children with educational support during the late afternoon when many children are home and supposed to be involved with their homework.

In the spring of 1984, KLCS in Los Angeles conducted a pilot program called "Homework Hotline" that was sponsored by the Los Angeles Unified School District. The program was aimed at mathematics and English instruction for junior high school students. It ran from 4:30 to 5:30 p.m. four days a week. The response was so strong (3500 calls for the 48 hours the program was running) that the school district paid for an expanded program that is still running.

In the California city of Irvine, the existence of community cable television has been taken advantage of by having older school children act as "experts" who answer calls on television and offer academic help to the callers. Informal reports indicate that the calling children take pride in asking interesting questions since only the "best" questions get on the video screen (the rest are handled by phone only). This approach has the added virtue of making heroes out of academically gifted students who can act as role models for younger children.

Television is not a necessary element in such phone-in programs. The Brooklyn Central Library runs a successful hotline for grades 1-12 supported by the New York City Board of Education, and similar programs exist in other cities. An important feature reported in such dial-in programs is that parents also use them, because they find it difficult to help their children with the mathematics curriculum that has undergone extensive changes since they were in school.

An ambitious experiment by the Canadian province of Alberta combines several features of the programs described thus far. Using satellites, the ACCESS network began, in January 1985, to offer a wide range of educational programming that will be available both in private homes and in special teleconferencing classrooms that allow ACCESS to take advantage of the interactive potential in modern television. In addition, an 800 number allows people in their homes to call in and participate in a number of the individual programs. ACCESS offers courses in mathematics, computers, language, the humanities, and sciences for people of all ages. Programming has been designed on the basis of a four-year marketing study of the kinds of educational programming Albertans believe will meet their educational, cultural, and informational needs.

Examples of the kind of activity indexed by these cases of mixed media systems are increasing rapidly. Whether their potential can be realized to make a difference in the mathematics, science, and technology education of students currently underrepresented in those fields is open to question. The resources for educating children are distributed in many sectors of our society; coordinating these resources in the service of our goals and ideology concerning equitable and excellent education involves research, policy, and practice in a dependence on factors we yet dimly perceive.

8 • Conclusion and • Recommendations

We began this review of context-based factors in educational achievement with a critical examination of the common sense notion that cognitive task and context can be analytically distinguished for purposes of addressing how noncognitive factors influence school performance. Our extensive review of the literature pertinent to promoting effective learning by recontextualizing instruction produces a linked set of paradoxes for every level of context examined: Many different educational interventions can be considered successful when used with varying types of students, yet education in the United States cannot be considered successful, especially for women and minorities as they encounter mathematics, science, and technology. Accounts for these paradoxes get deeply embroiled in arguments about methods, but they are also deeply intertwined with values embodied in social policies and political choices.

Specific Recommendations

We present our conclusions and recommendations in two parts. First we provide some relatively specific proposals linked rather closely to the research areas reviewed. Next we make some more general comments that apply to the entire area of concern.

Recontextualizing at the level of lessons. Several recommendations arise in connection with this level of context. Research is needed on the context-rich methods of instruction, including those that involve computer microworlds and those that include culturally valued and pleasurable content. The work needs to be extended into other domains in science, mathematics, and technological literacy, keeping in mind that recontextualizing the task can promote the appearance of more sophisticated cognitive activity on the part of students, but that the educators' responsibility to appropriate these skills for educational gain is not thereby replaced. The trick remains to build on these enhanced basics, with attention paid to other levels of context.

Classroom organization. Although we do not doubt the basic findings of the time-on-task literature that more effective learning time is related to the varying social organizations of lessons, more research is needed. The properties of standardized measurements of time on task should be examined to determine the extent to which analyses of time on task can be related to *process measures* of cognitive functioning as opposed to treatment of "on task" as a residual category. The educational practices, like subgrouping, that follow from this literature also need more careful consideration. We know that subgroups can be arranged that not only change the size of instructional groups but also change the quality of the interactions between student and teacher as well as among students. A major research need is to specify the circumstances that make activity-based lessons work on a regular basis, especially where there is heterogeneity of entering abilities among the students. We have some very basic questions about subgroupings: What is the ideal size? How can teacher and aides be most effectively used in student-led groups? Should subgroupings be relatively constant or change with time or activity focus? Are there some constraints on when in the process of achieving mastery or where in the curriculum activity-based lessons are most effective?

To move toward wider and more stable use of alternative grouping strategies, we need also to understand the implicit ideology and practical rationale underlying educators' decisions to group their students by ability and to prefer teacher-led to cooperative student-led groups. If teachers knew the research findings, would they be more inclined to try out new kinds of small group activity structures? Or is their reluctance the result of more subtle systemic factors relating to societal and institutional pressures to evaluate, track, and produce an elite group of students, even at the expense of the less powerful? What new kinds of teacher training would widespread adoption of activity-centered curricula entail? If teachers are exposed to children being successful in subgroupings that are more cooperative, peer oriented, and active, will this promote (1) the more widespread adoption of such alternative grouping strategies and (2) a different evaluation of the ability of children for whom expectations were initially low?

School-level factors. We need to know much more about the conditions that lead to effective school cultures and optimized student careers in school systems. Much work in the United States focuses on school effectiveness factors such as the "management generalizations," but the tie to value factors that may be the pump-primers for effective implementation is not sufficiently understood (cf. Purkey & Smith, 1983). To what extent are such factors identifiable within school settings, and to what extent do they depend on community-school interactions? The research on school placement encounters does consider community-school interactions, but this line of research needs to be extended to research on effective interventions. At a minimum, there is a clear need for a critical review of work that integrates the spatial organizational viewpoint of the effective schools literature with the temporal decision-making view of the literature on students' careers.

New technologies. We have written extensively about new technologies and their potential for reorganizing the context of education. A great many problems need to be addressed before the potential of technology can be expected to issue in solutions to the problems we have been posing.

One topic relevant to new technologies has been conspicuous by its absence in our discussions—the consequences of teaching computer languages. There is good reason for this omission. Existing evidence speaks strongly against the idea that learning a computer language will, in itself, result in any significant and generalizable cognitive change (Pea & Kurland, 1984). Rather, what is true of literacy more generally (Scribner & Cole, 1981) has proven to be true of computer literacy: The cognitive consequences depend on, and are specific to, the domain of cultural practices within which literacy is applied. Care must be taken to avoid simply repeating errors of the past.

A promising area of research in computer literacy and computer software development that makes contact with this review's focus on context and recontextualization is the use of authoring languages. Authoring systems allow users to go quite far toward designing their own piece of software, manipulating anything from content to graphic display to command structure. User definitions of software programs increase accessibility by different kinds of users; with an authoring language, the teacher and the learner have power to specify that pieces of the software be appropriate for the culture and gender of the user, even for specific individuals and applications. Few programs, however, at present, exploit this ability of current computer systems; thus a research priority issue is design and implementation of software that can be authored for and by local groups working on improving the education of minorities and women.

In addition to advising research and development on software that emphasizes authoring languages, particular software designs for particular populations have been suggested in this report. The research agenda should focus on software that (1) exploits analogies among domains, allowing entry via areas of believed strength (e.g., narrative) to areas believed to be difficult (e.g., science) and (2) blurs the so-called Level 1/Level 2 distinction, allowing the acquisition of basic skills within a framework that simultaneously motivates transformations on the input as well as rote learning.

Research needs to be focused on how to initiate and maintain curricula and teacher training that use effective participant structures to promote computer access for girls and minorities. Basic research on the quantity and nature of groups assigned to work cooperatively on computer-mediated tasks needs to continue, particularly with respect to interactions with varying characteristics of students, curricula, and academic tasks.

For both girls and minorities, special settings that include an emphasis on family and community have proved effective and challenge ideologies or practices that limit access in ordinary schools. Research should be undertaken in these settings investigating specific interactions between computer use and academic domains as should research that investigates the possibility of diffusion of such projects.

The telecommunication use of computers can be applied to educational domains resulting in variations in the temporal and spatial constraints of teaching/learning exchanges. Systematic research needs to be undertaken to examine whether such variations are particularly advantageous for increasing access and achievement by women and minorities. A particularly powerful use of the computer that has not been explored is in communication between institutionally and geographically distinct cultures. Research should be undertaken on the academic achievement consequences that might be mediated by changes in status and expectations when minority students in this country communicate with students in other countries; particularly interesting are effects that might accrue from communication systems that put minority students in contact with students and teachers who share their ethnic and language characteristics but who are "mainstream" in another culture.

Integrated systems. The success of the programs reported on by AAAS and the specificity of the analysis provided about the essential features of such programs provide a basis for research of two types: One involves change experiments that introduce missing essential features into programs that are failing to provide successful education to women and minorities; the second involves contrastive investigations of the essential features that emerge in institutions that are successful at science and technology education for minorities juxtaposed with the conditions in similar institutions where one or more of the essential features are inhibited and the agenda for success is not achieved. The emphasis on excellence over remediation, on vertical integration of members of the target populations at different points in their educational careers, and on the horizontal integration of education with other social institutions and activities are candidates for early emphasis in both of the suggested research approaches.

Two exemplary programs connected with University of California at San Diego illustrate the possibilities of practical integrated systems. Both programs are practical responses to apparent difficulties encountered by students from nonmainstream backgrounds, organized by professionals with ethnically nonmainstream backgrounds. Both programs run with very little expense to the university, and, in spite of the lack of resources for extensive research on program effectiveness, both are viewed as successful by members of the university community.

The UCSD Minority Honors Workshop (MHW) combines supplementary instruction in basic courses, peer-group study, and contact with corporate sponsoring groups to orient minority students to the possibility of excellence in their own educations. Students meet together for 8-10 hours a week for academic and social activities. The academic work is concentrated on the basic calculus course which is a prerequisite to all later science courses at the university. The social interactions include ongoing advising, monitoring of student progress, and meetings with successful college graduates working in industry. Important features of this program are its orientation toward enrichment and excellence, rather than remediation, and the heavy involvement of minority and female teaching staff. Students who participate in this program receive grades significantly higher than control group students who do not participate.

The Community Educational Resource and Research Center (CERRC) provides the kind of vertical integration that is called for in the AAAS report, emphasizing significant community input. CERRC is staffed by minority group PhDs with extensive teaching and research experience at the university level, but it deliberately operates as an intermediary between the community, the school system, and the university. Its goal is to provide for the reorganization and coordination of already existing resources devoted to minority group students' education.

To this end, CERRC staff teach a "practicum" course at the university that combines basic theoretical work in computer technologies and educational psychology with field work in afterschool schools (called *jukus* like the afterschool institution in Japan), located in minority-impacted neighborhoods with high dropout rates. The CERRC *jukus* teach basic skills combined with computer literacy. In particular, the computer is used as a means of communication; each afterschool center is linked by a messaging system to other centers within the San Diego area, to the university, and to a board of university scholars located in various parts of the world.

The CERRC system includes not only elementary school students but "upward bound" high school students, university students, doctoral students, and postdoctoral fellows. It manages all of this by coordinating resources from the academic program of the university as well as support service units. It has proven successful as a training site at all of these levels, providing one of the clearest cases of using new technologies to make possible the kind of program integration that exemplary programs seem to require without a large infusion of new financial resources.

Research connecting school and nonschool contexts. All evidence points to the utility of programs coordinating school efforts with alternative institutions also interested in children's education. Effective programs appear to combine basic research and educational intervention in a single project and to arrange for a two-way flow of information between the school and other social institutions, like homes and communities. Ways to amplify those efforts should be explored, as should the tremendous potential of various media in such projects.

Our society is at the beginning of very exciting advances in media. There is a particular need to look into ways of combining mass media, communications systems, and computers: For example, a televised homework-hotline could be combined with the telecommunication of computer graphics that could promote more Socratic hands-on help and/or that could allow questions to be asked on those topics where "words fail." Other examples can be borrowed from the use of multiparty multimedia teleconferencing in business, where advances in software and user interfaces allow for mixtures of real-time and offline communication as well as for easily changed manipulations of group size involved in a topic discussion; in an educational application of this technology, peer groups could be manipulated and peer or adult-child dyadic communication could evolve as the topic and abilities of the students required. These are important areas for research and dissemination, but programs need to be carefully evaluated and essential features need to be identified.

General Comments

The following comments are common to virtually all levels of the analysis of contextual factors in education. While methodology and uptake may be pointed to as problematic in any review such as this, they are particularly important here because so much of our work calls for multidisciplinary and multi-institutional involvement in the improvement of educational systems.

Questions of methodology. Methodological advances are needed to accomplish much of the preceding recommended research. Recontextualization within and between the various levels of context appears to be a very powerful tool for increasing the quality of learning time, but it faces difficulties from at least three sources: the current state of the technology of academic psychology, inadequacies of interdisciplinary scientific discourse, and problems with social relations needed for long-term studies.

Contemporary psychological research has developed sophisticated strategies for collecting data and assessing levels and rates of learning and development, but there are two important limitations. First, the methodological machinery works on cases where much care is taken to isolate the subject to promote independent activity; recontextualization implies the need to assess learning and to design instruction where joint activity is a central issue. Second, psychological research has progressed from the use of "product" measures to online process measures; but the need to study nonlinear systems of interaction, as much of the research recommended here calls for, is difficult to accommodate; thus there must be research on how to maintain the gains made in psychological research while examining phenomena with characteristics like embedded contexts and non-real-time communication.

The multidisciplinary nature of the recommended research brings up other methodological concerns that should themselves be researched. Ethnographic research and psychological research have been carried on in tandem, and some of the most effective programs are characterized by integrating these disciplines with educational practitioners. Yet the three-way alliances are often uneasy; research on effective interdisciplinary work is needed.

Part of the methodological problem is one of evidence and science; how do we make qualitative data quantitative without losing the essential systems properties needed to produce change? Owing to the lack of research of the kind we are calling for, we have been forced in this report to include various "summative evaluations" of instructional interventions which can be criticized for a variety of reasons. But the criticisms are not so severe in their aggregate as to leave any doubt that, given proper increments in energy and resources such as accompanied the curriculum reforms of the 1960s, it is technically possible to make a difference.

A related concern is the need for longitudinal studies of full systems related to educational interventions. There is reason to doubt that effective change can be engineered if the innovations are limited to one age group or one part of the embedded context structure; rather than reducing the problem to its parts and abstracting from laboratory study of elements in the process, we need to address the whole question: How can we organize schools so that they "satisfice" for society in a way that includes more mathematics, science, and technology? To address these issues realistically and seriously will entail multidisciplinary work that is funded over a period of years. While summary research based on secondary analyses can certainly be useful (e.g., AAAS, 1984), many questions can only be treated in a thorough way (that will both profit from and influence scientists, educators, and policymakers) with a longitudinal project that has extensive and stable funding.

There are practical problems that must be addressed to institute long-term multidisciplinary projects that will impact educational practice. First, there must be new mechanisms for linking subject-matter specialists (from universities, museums, business, etc.), teachers, and students for long-term coordination and cooperation. Second, there must be serious involvement of other parties, including social scientists with a strong voice and interest in local community concerns; to paraphrase the AAAS's recent report, effective program development, targeted for women and minority students, entails the involvement of social scientists who look like the people presumably being served. At one time there might have been complaints that no such people exist. The prominent place of minority group researchers cited in this report indicates that this barrier has been overcome. This is a positive outcome of 1960s academic activism.

The problem of uptake. A sobering issue that is raised by this entire discussion and that needs to be addressed in the next round of serious work on this problem is the lack of uptake when innovative programs prove to be successful. This constant "failure in the face of success" speaks to the need for a thorough analysis of the sociohistorical context. It is a big problem. It appears that the sum total of negative factors weighing against program innovation creates a Catch 22, which seems to be operating something like this:

> To address the problems of educational achievement among minorities and women, a special program is mounted with extramural funds. When the program succeeds, that source of funds is no longer available because it was for program *innovation*, on the assumption that successful programs would be taken up by the sponsoring institutions. However, these institutions have no provision in their budgets or programs for uptake; they would have to dislodge already entrenched programs, which they are not willing or able to do. So the successful program dies away. Then the problem is rediscovered, a new program is put in place, and the process begins over again.

It is our judgment that a hard look at the funding mechanisms and institutional constraints on targeted programs such as the exemplary kinds under discussion should be a part of any research effort on contextual factors and education that seeks to be especially relevant to minorities and women. That statement is quite a mouthful, but on the basis of existing evidence it appears that there are systemic features operating at the institutional level that hinder the uptake of demonstrably successful programs. If that is the case, monies will simply be spent to reinvent the wheel and create more bad feelings about the failure of educational research to have applied relevance.

It is in this overall context that the problems and promises of the new information technologies appear most hopeful. It is now technically possible to create communication between hitherto distinctive contexts in qualitatively new ways that have powerful quantitative implications. The greatest danger is that this potential will go unexploited; to exploit it would mean to render permeable currently impermeable barriers to increasing the educational performance of those now most distant from the frontiers of science and practice. These impediments are constitutive of the system as it is; to get ahead of events, we will need a stronger theory and the will to act on it.

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Appendix: Organization and Members of Subcommittee

Organizational Structure

At an early point in deliberations about productive ways in which to address the issues before us, it was clear that an unusual group of scholars would have to be assembled. Although nominally framed as falling within the purview of the discipline of psychology, our emphasis on context meant that we would have to call on people who had worried about the context of instruction, which implicated anthropologists, sociologists, and linguists as well as psychologists. In addition, the charge to focus on special issues involving minorities and women made it important to obtain experts from the groups so designated.

In response to this challenge, we contacted scholars from different parts of the United States representing the full range of expertise we believed necessary to our task. All of these scholars agreed to deliberate with us for the first several months of the project with the understanding that an appropriate subset would meet together at a later time to pool their information and to draft this report. On December 10 and 11, 1984, 28 people participated in a two-day workshop, bringing with them texts of proposed sections and writing during their time together. This group was evenly divided between minority and nonminority scholars; slightly more than half the participants were women.

Given the geographic and disciplinary distance separating participants, we hit on the strategy of using computer networking as a means of speeding the process of information accrual and discussion to supplement information exchange via the mails and "hard copy." We were not convinced that there was any advantage to be gained by creating a computer conference, but it appeared likely that, with respect to the impact of new technologies on contextual factors in education, networking systems that rearrange the contexts of interaction were a promising area to investigate.

By trying out a conferencing system, committee members could assess for themselves the problems associated with the highly touted medium of telecommunications.

Using resources provided by the Laboratory of Comparative Human Cognition at the University of California, San Diego, which is involved in teleconferencing on an international basis, a bulletin board was created which began to operate well before participants arrived at UCSD for the face-to-face conference. The bulletin board continued to operate following the December meeting, as participants created revised texts and discussed their growing understanding, facilitating the production of this document.

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The following scholars commented on the initial draft document and made substantive suggestions that have been incorporated in the published version.

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